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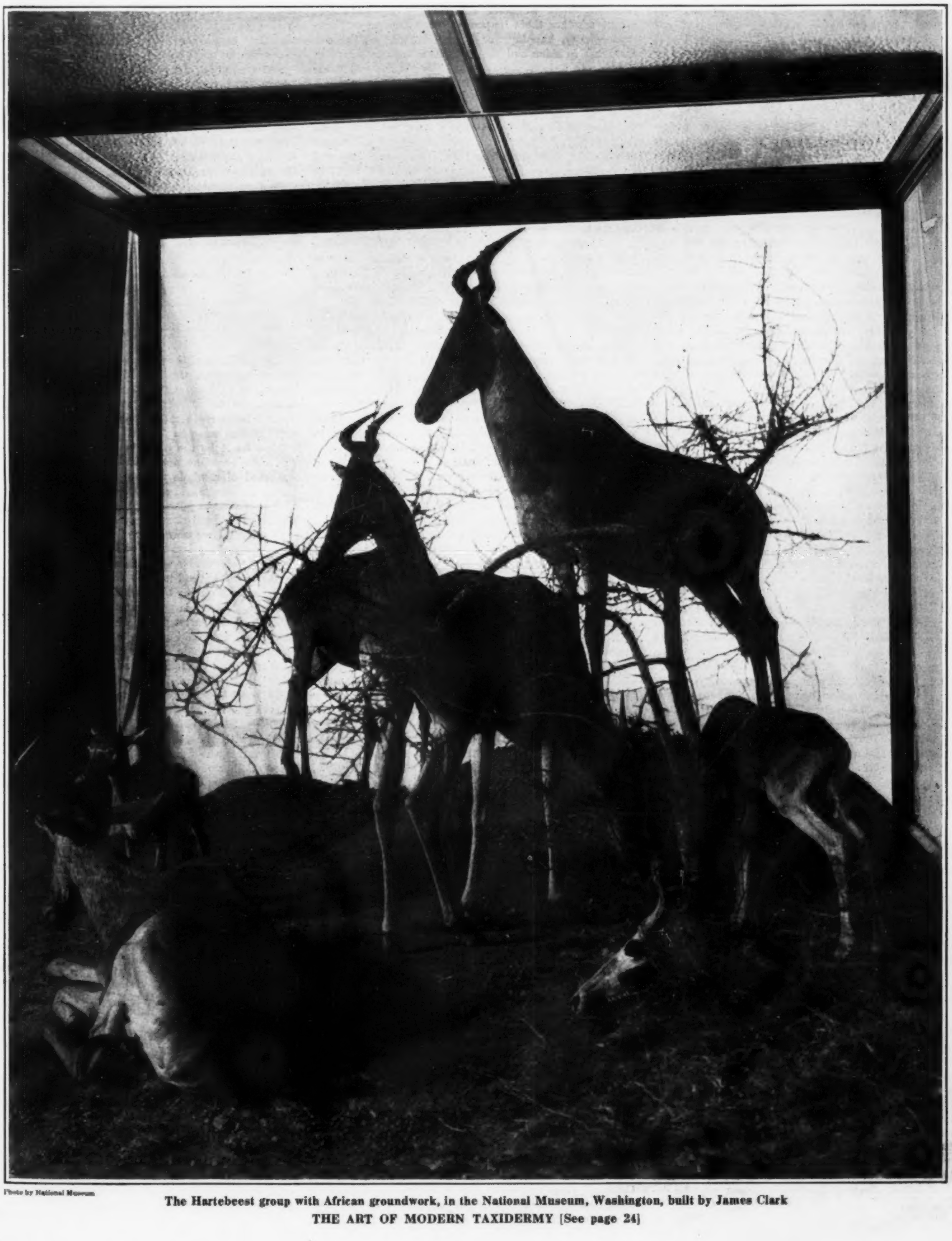


Photo by National Museum

**The Hartebeest group with African groundwork, in the National Museum, Washington, built by James Clark**

**THE ART OF MODERN TAXIDERMY** [See page 24]

# Natural Measurement of Time—I.*

## The Year and Its Limitations

### By N. F. Dupuis

In considering the length and limitations of the year it becomes necessary that we at first define the word *year* so as to know exactly what is meant when we speak of it.

A year is the length of time taken by the earth to make one revolution about the sun, starting from some indicated point in its orbit, and returning to the same point again. That the point should be fixed in space is not an element of the definition, for it is doubtful if we can know anything about absolute fixity in space. It is enough that the point should be of sufficient prominence in the theory of planetary motion to make it a point of importance.

Astronomers define three different years, or rather three kinds of year depending upon the particular points taken. And over and above these there is the calendar or practical or civil year, that is, the year used in and for the practical purposes of life. This last, although derived from one of the defined years, is variable in length and is not strictly definable.

The three years defined are not of equal importance from the point of view here set forth, and the first two that we shall consider are of very little importance except to the astronomer.

*Anomalistic Year.*—The anomalistic year is the length of time taken by the earth to go from the perihelion around to the perihelion again; or, for the sun, apparently, to go from any given anomaly to the same anomaly again. The perihelion point is taken as the point of reference, and the anomalistic year begins when the earth is in perihelion, which in the present year of our Lord is not far from the first of January.

The sun's angular diameter, as seen from earth, is a function of the sun's distance from the earth, and as this angular diameter is easily measured, the variations in the sun's distance are easily determined. So it is quite a possible and practicable operation to find when the sun is nearest the earth, or when the earth is in perihelion, and accordingly when the anomalistic year begins.

In this way it has been discovered that the perihelion point is not a fixed point in relation to the general positions of the stars, but that the apsis line has a slow progressive movement, that is, a rotation in the same direction as that in which the earth moves in its orbit.

In this manner the length of the anomalistic year has been found to be 365.2595 days.

*The Siderial Year.*—The siderial year has no intimate connection with the siderial day or with siderial time, and it is usually defined with a star as a fixed point—thus a siderial year is the length of time required by the sun, in its apparent annual motion about the earth, to go from a given star around to the same star again.

But the stars instead of being at rest, have each its proper motion so that siderial years determined from a number of different stars might not be altogether consistent with one another. This difficulty is to be overcome by either finding a star which is absolutely at rest—a difficult if not an impossible undertaking—or finding the proper motion of some individual star, and then allowing for this motion when determining through this star the length of the siderial year.

To give some idea as to how this may be done, let us suppose that there are two stars affected with the same, or about the same, linear proper motion, and that one of these stars is ten times as distant as the other. Then the angular motion of the near star would be ten times as great as that of the distant one, so that we have the proper motion of the near star to within one-tenth of its true value. And as all these motions are exceedingly small when taken for a single year, and as such observations can be repeated at liberty with stars very much more distant than our supposed one, the proper motions of all the nearer and brighter stars may be determined to within very close limits. The length of the siderial year is thus found to be 365.2567 days, which is 0.0028 days, or about four minutes shorter than the anomalistic year.

It may be said in passing that the only use of the siderial year is to act as a basal period of time in fixing quantitatively the progression of the perihelion and the retrogression of the equinox, or, as it is generally called, the precession of the equinox.

*The Equinoctial or Tropical Year.*—As its name indicates, this year has a relation to the equinoxes, and the point of reference here taken, in order to fix the length of the year, is the vernal equinox, or the first point of Aries. So that the tropical year may be defined as the time taken by the sun, in its apparent revolution about the earth, to pass from the vernal equinox around to the vernal equinox again.

This is the period of time popularly known as the *year*, and its importance is manifest in all our seasonal relations. And whatever may take place upon this earth—whether there be peace or war, famine or bounteous plenty, happiness or misery—as long as the sun continues to shine and the earth to move in its wonted course, the orderly procession of the seasons will never fail.

In very early times, when possessed of the crudest of astronomical ideas, and when such things as perihelia and anomalies and siderial years were unknown, man found it necessary, in some way, to connect the length of his year with the orderly return of seed-time and harvest, for these latter things are mainly dependent upon the varying positions of the sun in relation to the equinoxes. That is to say that he found it necessary to establish in some way, however crude, an approximation to the length of the tropical year.

The problem of finding the true length of this year has been a problem of the ages, and although attempts at its solution must have begun with almost the beginning of man's intelligence, its complete solution has been attained to in only comparatively modern times.

It is sufficient to say here that this complete solution has shown that, at the present time, the length of the equinoctial or tropical year is 365.2422 days, and that it is thus 20 minutes and 53 seconds shorter than the anomalistic year. Moreover, it is highly probable that this length may vary to the extent of a second or so in a century.

Having stated the problem of the length of the tropical year and given the results obtained, we next go on to consider the means employed in the solution.

#### THE YEAR

Although the tropical year and the seasons are so intimately connected together as not to be separated, yet it is not practicable to determine the length of the year, or its beginning, or its end, by any reasonable amount of observation upon the course of the seasons. The phenomenon of "winter lingering in the lap of spring" and others of like kind are too numerous to allow of any exact fixing of the beginning of a season by means of the weather or anything depending thereon; and we are finally compelled to resort to the motions of the sun in order to get definite results.

Thus, the mean sun, in its apparent annual course about the earth, passes through the equinoxes and the solstices—the equinoxes being the points where the ecliptic crosses the celestial equator, and the solstices being the points in the ecliptic farthest distant from the equator, one being north and the other south of the equator.

Then, in the northern hemisphere, *spring* begins when the center of the mean sun is at the first point of Aries, or the vernal equinox. About three months after this, *summer* begins, the center of the mean sun having arrived at the summer, or northern, solstice. This is the first point of the constellation *Cancer* in the conventional zodiac.

After another three months the center of the mean sun arrives at the autumnal equinox, and the season of *autumn* commences. This is the first point in the constellation *Libra*. Going on for another three months the center of the mean sun arrives at the winter solstice, or the first point of the constellation *Capricornus*, in the conventional zodiac, and *winter* begins. In another three months the sun returns to the vernal equinox, and the year is completed.

Thus, the seasons and their limitations are absolutely defined by the motion of the sun, and these definitions are exact, no matter what may be the character of the prevailing weather in any season or on any part of it. And all agricultural and horticultural operations are naturally carried out in dependence upon the seasons as now defined.

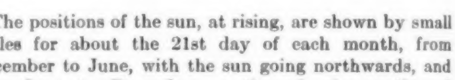
To observe and measure the apparent motion of the sun as for six months it moves from the summer to the winter solstice, and for six months moves in the opposite direction, is easy enough for modern astronomers armed with all necessary telescopes, measuring instruments of all kinds, and other paraphernalia for the purpose.

But it was different with the pioneer of four or five thousand years ago, when astronomy was in its infancy, when the only telescope employed was built upon the ground and had to serve the purpose of both observatory and temple, and when the sundial and the clepsydra furnished the only means of counting the smaller internals of time. And yet these pioneers succeeded, in a very ingenious manner, in keeping count of their years and confining them to the four seasons.

Even a superficial observer must notice that in the northern hemisphere—and where not necessary to do otherwise we shall confine ourselves to this hemisphere—the sun comes northward in the summer time, and moves away to the south in winter, the whole extent of the excursion being about 47°, or more exactly 23° 27′ on each side of the equator. And a little careful observation will show that, with our present division of the year into months, the sun rises and sets farthest north of the equator about June 23d, and farthest south of the equator about December 21st.

And as the seasons and the length of the tropical year are determined by these solar excursions, we have, in them, a proper and convenient index of the passing years.

These results are illustrated in the accompanying diagram where the horizontal straight line denotes the eastern horizon as seen over a level plain.




The positions of the sun, at rising, are shown by small circles for about the 21st day of each month, from December to June, with the sun going northwards, and from June to December, southward, the northward motion being represented above the line and the southward motion below it.

Now let $A$ be the point in the horizon at which the sun rises on some particular day. Then, if the year consisted of a whole number of days, one year afterwards the sun would rise exactly at the point $A$ again. But because the year is not a whole number of days, the sun would not rise exactly at $A$ when the year came around. But we now know that the error in one year would be slightly less than one-fourth of the sun's daily motion, and that by the accumulation of errors the discrepancy would tend to right itself after a series of years.

Thus, by counting the days from that upon which the sun rose at $A$ when going northward, to that in which the sun rose nearest to $A$ when going northward the next time, we would get the length of the tropical year to the nearest whole number of days. The error would correct itself by adding an additional day to the year when required, and it is therefore not accumulative.

This will be considered more fully under the calendar or civil year.

This method, however, although connecting the seasons with the year in perpetuity, could not give us the true length of the year unless by averaging a very large number of the yearly results so obtained.

Observations of this kind could readily be carried on by setting a number of stakes on an extended plain, or by otherwise permanently marking out a line, directed to $A$, or to any practicable point on the eastern horizon, if the sun's rising is to be observed, and to the western horizon if the setting is to be observed.

The ancient Egyptians, among other early people, employed this method of getting at the length of the year and of connecting the year with the seasons. But to the ancient Egyptians the sun, the moon, and many of the bright and significant stars, were gods, or in a way represented gods. Thus it appears on good authority that the rising sun, the bringer in of the morning and the light, and the extinguisher of the stars, was Horus. The sun in his strength and brightness, when high in the heavens, or at noon, was the great god Ra; and the setting sun, when leaving the world of the living and going down to cheer for a while the underworld of the dead, was Osiris. So that to these people astronomy and religion were, to a great extent, one and the same thing, and the priest was at the same time the administrator of all religious ceremonies and the astronomer.

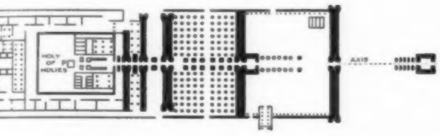
And instead of depending on anything so frail and commonplace as stakes to line out the position of the rising or the setting sun, they built huge and wonderfully complex temples with long and narrow axes directed to some desirable point of the horizon, and through which the sun's rays might pass into the holy of holies, at rising or at setting, on certain days only as determined by the particular orientation of the temple.

*From *Queens Quarterly*.

Of these grand old temples, the work of a giant-nation of builders, little now remains but masses of ruins, their usefulness gone and their religious ceremonies living only in ancient history, while a few of their titanic monoliths have been scattered throughout the world to form interesting ornaments for strange cities.

The temple of Amen-Ra at Karnak, in upper Egypt, when in its glory, was probably the greatest structure ever reared by the hands of man, and which now forms the most extensive ruin in the world. The total length of this temple was about 1,600 feet, and it covered an area fully twice as great as that of St. Peter's at Rome. It was oriented to the setting sun at the summer solstice, presumably because the western horizon offered the better view.

The following illustration is of a plan of the temple, in which the open axis, throttled down by numerous narrow passages between pylons and columns so as to prevent the passing of extraneous rays, is clearly shown. At $S$ is a double row of sphinxes, and at the proper time the rays from the setting sun—which in Egypt shines from a cloudless and mistless sky—threaded their way through the long, narrow axis and fell upon the altar $P$ in the holy of holies, and indicated to the attending priest that the sun had arrived at the summer solstice.




In regard to the method of accommodating the year to the seasons as now described, it may be worth while to make a few remarks.

The apparent movement of the sun from north to south and back again is harmonic in character, so that it is slowest, coming to rest for a moment in fact, at the solstices, and greatest at the equinoxes. As a consequence the sun's rays, when at a solstice, might penetrate into the holy of holies for several days in succession, while they could not do so for more than a couple of days, at most, in a temple oriented to the equinox.

It appears then that temples oriented to a solstice were much more uncertain in their determination of the particular day of the solstice than one oriented to the equinox would be in regard to the particular day of the equinox.

Why the great temple of Karnak was oriented to a solstice we do not know; possibly on account of the lay of the country, or for some reason connected with the religion of the people. Some temples are known to have been oriented to the equinox, as was Solomon's temple, according to Josephus.

However, either case would give results sufficiently close for agricultural and sacrificial purposes, and, as said before, the error, whatever it may be in any particular year, cannot amount to over a couple or three days at most, and it is not accumulative.

Although the orientation of a temple to a solstice may have served its intended purpose for some centuries after its builders had passed away, yet owing to the slow secular change by which the obliquity of the ecliptic is decreasing in amount, the extent of the sun's annual oscillation was, and still is, growing less from century to century, and after a few thousand years the sun's rays would no longer be able to penetrate the axis of the temple, which would therefore lose its astronomical value.

Temples oriented to the equinox would undergo no change in their astronomical value, and those to any other point might be only slightly affected. So that whatever may have been the reason for orientation to a solstice, it was the worst of all orientations that could be made, and this for two reasons, that it was more uncertain in its indications, and it was sure to fail after a considerable lapse of time. Any individual temple could give, at most, only two points or periods in the year, and if oriented to a solstice, only one period, which would naturally be taken as the beginning of the new year.

But the early Egyptians, as well as other people, found it necessary to divide the year into parts or seasons just as we do. For, some phenomena, such as the rising of the Nile, was to them of such vital importance, that it was seemly to celebrate it by some religious ceremony. And all such matters had to be arranged and prepared for by the priest-astronomer. This division of the year into certain seasons could have been done by orienting temples to different points, as required, within the limits of the sun's annual oscillation, and it is quite possible that some of the many temples scattered over the country may have been so oriented.

But this pioneer people had another method of solving this latter problem, and this we proceed to describe: The sun, in its apparent annual journey about the earth, passes from west to east among the stars in the vicinity of its path. So that a star that is east of the sun by a small amount today will be west of the sun after a few days. Now when a star is east of the sun it rises after the sun, and is lost, or unseen, in the surrounding brightness of the sky. But when it is west of the sun, but not far distant, the star rises a little before the sun and may, if it be a bright star, be seen to rise in the morning dawn just before sunrise. In this latter case the star is said to rise *heliacally*. As there are several bright stars in the vicinity of the ecliptic, or sun's apparent path in the heavens, the year can be divided into periods and seasons, with considerable accuracy, by observing the heliacal rising of these stars as, one after another, they take their places in the order of rotation. And as it was the business of the priest to watch for the dawn and the rising sun, it was his business also to detect the first glimmer of a heliacally rising star as it preceded the sun and rose in the brightening dawn.

This very natural method of indicating the coming in of various seasons was in use among many nations of the past, and continual references to it are to be found in ancient classical writings. But this usage of appealing to the stars necessarily introduced, into the count, time as measured by the siderial year. And, as the siderial year is longer than the tropical year by about 21 minutes, the season as determined by the heliacal rising of a star became later from year to year, and after a time became so far out that the star was abandoned in favor of some other that suited the purpose better. Some of the heliacal risings referred to in the writings of Vergil bear evidence of having been adopted at a date fully 2,000 years before Vergil's day, and such references are often to be looked upon as being traditional rather than of any practical use at the time in which the author lived and wrote.

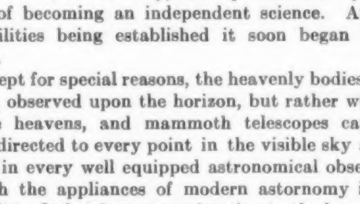
Ancient Egypt, as far as pure astronomy was concerned, was badly handicapped by the circumstances—first, that the subject was in the hands of the priests and was a part of their priestly education, and that it was, in consequence, surrounded and filled to overflowing with crude religious ideas and numerous religious forms and ceremonies, calculated not so much to teach the people anything as to awe and impress them with the power and importance of the priesthood. And, second, that their only telescopes—or what took the place of telescopes—were temples, built even more for mysteries and occult ceremonies than for real astronomical observations. Observations on a heavenly body by such a telescope could be carried out only when the body was on the horizon, that is either at rising or at setting, and even then only when the temple had a proper orientation. Hence the repeated references and invocations to the horizon, and the double horizon meaning the eastern and the western horizons.

It was only after astronomy threw off the nightmare of theology, and became free to follow and discuss its theories in its own way, that possibilities opened up to it of becoming an independent science. And these possibilities being established it soon began to forge ahead.

Except for special reasons, the heavenly bodies are not, today, observed upon the horizon, but rather when high in the heavens, and mammoth telescopes capable of being directed to every point in the visible sky are to be found in every well equipped astronomical observatory.

With the appliances of modern astornomy it is not difficult to find a close approximation to the length of the tropical year, but, of course, it must be borne in mind that accuracy in result follows only laborious and painstaking accuracy in observation.

We shall briefly explain here how the position of an equinox may be found—for the sun occupies a tropical year in passing from an equinox to the same equinox again.




In the figure, let the horizontal line $Eq$ represent a part of the celestial equator near a node, and let $Ec$ represent the ecliptic crossing the equator at $A$, the ascending node. Now as it is not probable that the sun will be at the node exactly at noon, let $s$ be the sun's position at the noon before it reaches the node, and $s'$ be its position at the following noon.

Then $sm$ is the sun's declination at the first noon considered, and $s'm'$ is its declination at the next noon, and both of these can be observed and measured quite accurately by means of the transit instrument.

Denote these declinations by $\delta$ and $\delta'$ respectively. Then we have, from similar triangles, the relation—

$$mA : mm' = sm + s'm', \text{ or } \delta : \delta + \delta'.$$

$$\therefore mA = \frac{\delta}{\delta + \delta'} . 24 \text{ hrs., since } mm' = 24 \text{ hrs.}$$

The following will serve as an illustration:

On March 20th, 1882, the declination of the sun at noon was observed to be 0° 4′ 53″ south and on the 21st at noon the declination was 0° 18′ 49″ north.

$$\text{Here } \delta = 293'', \ \delta' = 1129'' \ \delta + \delta' = 1422''.$$

$$\text{and } mA = \frac{293}{1422} \times 24 = 4^h\, 56^m\, 33.^s$$

That is to say that in the year 1882 the sun was at the ascending node at $4^h\ 56^m\ 33^s$ P. M. on March 20th. And thus for any year we can find, by direct observation, the time when the sun arrives at the ascending node, and hence the length of the tropical year.

For finding the mere length of the year it matters very little whether we consider the true sun or the mean sun. But if we are in search of the beginning of the year—assuming it to begin when the mean sun arrives at the vernal equinox—it is necessary to reduce the observations on the true sun so as to apply them to the mean sun.

[TO BE CONTINUED]

## Paper-Yarn Textiles and Dyeing and Impregnating Them

The manufacture of paper-yarn textiles in Germany has been stimulated in an extraordinary degree by the war. The industry may be considered under two branches: the manufacture of substitutes for jute sacking and the manufacture of textiles for ordinary use. Very great progress has been made in a technical sense in the manufacture of jute substitutes; the satisfaction of the requirements as regards high tensile strength presented considerable difficulty, on account of the shortness of the paper fibre, but improved results have been attained by certain after-treatments, notably by suitable impregnation. This branch of the trade is essentially a war industry, the material being employed mainly for sand bags, and the question of its continuation after the war remains more or less open. Nevertheless, it is hoped that the substitution of the entirely home-manufactured product for the imported material may be permanently established after the war, more especially since it is shown that the price of jute increased 120 per cent during the twenty years from 1893 to 1913. Other materials have advanced in much lower ratio, *e.g.*, cotton 47 per cent, wool 43 per cent, raw silk 2 per cent, flax 30 per cent. The quantity of raw jute imported into Germany in 1913 was 162,063 tons. and even as compared with 1910, the price showed an advance of 76 per cent. The manufacture of the finer grades of paper textiles for general purposes shows even better prospects for the future; the technical progress made during the period of the war is most striking when products of the present day are compared with those of three years ago. Yarns of different character are required for this branch of the trade; the cotton manufacturer requires yarns and fabrics of greater softness. It has been found that a textile finished by calendering from a weakly alkaline soda or soap bath becomes much softer and more pliable. It is expected that public taste will be trained by the present scarcity of the standard textile fibres to take these new materials into favor for decorative printed goods and wearing apparel and that the demand will go on increasing after the war. As regards the impregnation of paper yarns to increase their strength and resistance to moisture, it has been found that the treatment with aluminium soaps as practised with cotton goods does not give such satisfactory results in this case. The best treatment is by impregnation in two baths: (1) passage through a glue, tannin, and silicate bath at 50° C. without drying, and (2) passage through a cold basic aluminium formate bath of 6° B. (sp. gr. 1.04), and drying. The first bath is made by steeping 80 grms. of glue in cold water for several hours and then melting. In a separate vessel 1.5 grms. of tannin is dissolved in hot water and 1.5 grms. of water-glass of 36° B. (sp. gr. 1.31) is added. The glue solution, heated to 50° C., is then treated with the tannin-silicate solution, while stirring, and the whole made up to 1 litre. The impregnated yarn shows an increase of over 10 per cent in dry tensile strength and about 30 per cent in wet strength. The dyeing of paper yarns and fabrics is done exactly on the same principles as that of cotton. Substantive, sulfur, and vat dyestuffs are employed, but greater care is required in turning and handling the goods. Dyeing machines are perferable to hand dipping on this account, and for the same reason the baths must not be too strongly alkaline and the temperature must be kept below the boiling-point, perferably at 50° to 60° C.—*Note in Journal of Society Chemical Industry, in a paper by A. Kertesz, in Ver. deut. Textilveredlung.*

# The Impact Origin of the Moon's Craters*

## Features Peculiar to Lunar Physiography

By Donald Putnam Beard

QUITE recently there has been a revival of the old discussion concerning the origin of the enigmatic features which our satellite, the moon, betrays; features peculiar to lunar physiography alone, and which find no mundane counterpart. Until within a score or more of years the time-honored volcanic doctrine of causation of those great circular mountain ranges termed "craters" has held well-nigh undisputed sway.

This misapprehension as to the true origin of the lunar craters is a traditional opinion handed down to us from the days of Galileo's "optik tube," and is still held by many leading investigators, notably Puiseux, of the Paris Observatory, Professor W. H. Pickering, H. Ebert of Munich, E. W. Maunder of England and other noted investigators. The word "crater," primarily derived from the Greek name of a kind of bowl or cup, has unfortunately come to possess an implication of specifically volcanic origin when used in a geologic—or lunar—sense.

Perhaps the oldest theory of the volcanic origin of the lunar craters was that advanced by Robert Hooke in his "Micrographia," circa 1667.[1] In this work he suggested that they are caused by the bursting of Cyclopean bubbles in the once viscid surface of the moon, which

Fig. 2. The lunar crater Theophilus, (0.6; 0.8); from a Lick negative. The position of a crater in these photographs is indicated by two numbers in brackets. The first number gives the distance of an object in inches and tenths from the left-hand edge; and the second its distance from the bottom edge, as in W. H. Pickering's atlas of the moon. This is a typical lunar impact crater, from 17,000 to 19,000 feet deep, and 64 miles in diameter.

later solidified into the crater rings. However, this theory fails to account for the vast proportions, the central peak, the inner plain and other fundamental features inherent in lunar craters, and therefore does not commend itself to serious consideration.

A more rational hypothesis is the tidal-stress theory, which had its inception simultaneously in England, France and Germany[2] and is based on the tidal influence of the earth upon the moon. If, as Professor Sir G. H. Darwin has mathematically postulated,[3] the moon was sundered from the semi-solid primaeval earth rotating on its axis once in about four hours, the former must have revolved in close proximity to the latter for several millions of years. Tides of unimaginable magnitude were raised by each in the other, and these enormous tidal-stresses are supposed to have ruptured the viscid lunar crust into fissures, from which exuded the inner liquid lava. With the passage of the tidal wave, the lava retreated within, but not before congelation, arresting the flood at its edges, marked its boundaries by a solid circular range.

A few fatal objections, however, may be advanced which this theory does not satisfactorily meet. The alternate extrusion and retraction of lava would have divided the entire surface into a close plexus of cracks, such as are seen in drying mud or concrete. This result of tidal-stresses is not observed on our satellite, save in a few instances, and these are referable to another origin. Again, according to this theory, the larger craters must have taken precedence over the smaller in the order of formation, and at an epoch when the viscid surface would not possess sufficient rigidity to sustain the massive crater formed. Furthermore, as will be shown later, the moon could never have undergone fusion in the gathering together of her mass, and consequently that *primum mobile* of volcanic forces, a molten and viscid interior, was never achieved in the early dawn of our satellite's evolution.

The idea that the moon's craters were formed by the impact of gigantic meteoric bodies apparently originated with Gruithuisen, a German selenographer, some fifty years ago. The late R. A. Proctor mentioned the

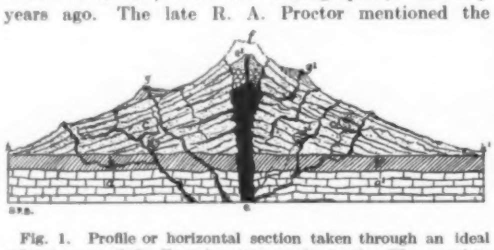


Fig. 1. Profile or horizontal section taken through an ideal volcanic vent of the Vesuvian type on the earth. The complete dissimilarity demonstrates emphatically that the terrestrial volcanoes and lunar "craters" have not known a cognate origin but are caused by widely different forces.

meteor impact theory at some length in his book. "The Moon,"[4] and later advocated this theory.[5] More recently the late Simon Newcomb referred to it as an astronomical curiosity in his text-book, "Newcomb's Astronomy."[6]

But the analytic development of Gruithuisen's original idea into a coherent working theory of the origin of the moon's features is due to a geologist, Professor Grove K. Gilbert, of the United States Geological Survey. In his classical address as Retiring President of the Philosophical Society of Washington, 10th December, 1892, Gilbert gave exhaustive consideration to the origin of the rugged and precipitous craters, the dark plains or "maria," the bright streaks radiating from Tycho, Copernicus and other craters, together with several anomalous features which lend such striking emphasis to a phase or full view of our satellite. He concluded that the impact theory best explained the phenomena included within its purview.[7]

Since they are the dominant feature of a first-quarter

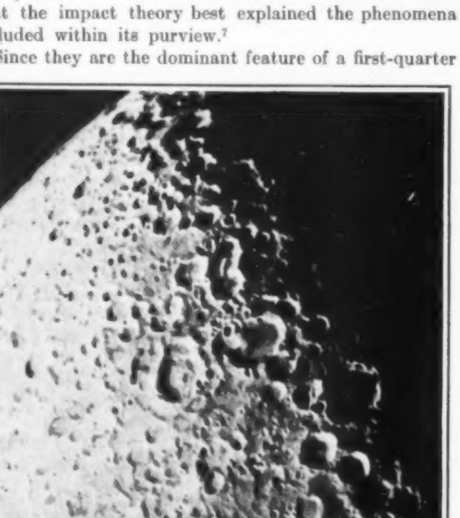


Fig. 4. Portion of the "great Southwest" region west of Tycho, from a Lick negative. Maurolycus is shown above the center (0.8; 0.9). The crater Maurolycus is a good illustration of the overlapping and partial obliteration of a smaller crater, formed earlier, by the impact of a larger moonlet.

view of the moon, primary consideration will be accorded the craters.

*The Craters.*—When one surveys the moon about first quarter by aid of a good glass, the sun is then seen rising upon the rough and jagged craters in the zone of sunlight near and along the terminator, their loftiness magnified by the spire-like black shadows they throw across the plains. Seen thus, these peculiar objects reveal themselves as deep circumvallations with steep and disordered terraces akin to "landslip" terraces on the earth, varying in size from such as Clavius, Schikard and Petavius (respectively 143,134 and 93 miles in diameter), down to the cup-shaped crater pits an eighth of a mile across, appearing as minute "pin-holes" in a large telescope. The selenographer Neison classified them as crater pits, craterlets, craters proper, crater plains, ring plains, mountain rings and walled plains, recognizing gradation between the craters and maria. Accordingly, they are all to be regarded as intergradations or phases of a single species; all owe their origin to a common cause.

The prevailing theory is to the effect that the lunar

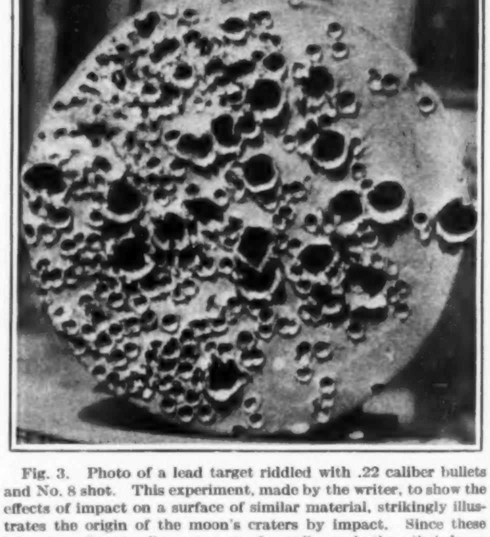


Fig. 3. Photo of a lead target riddled with .22 caliber bullets and No. 8 shot. This experiment, made by the writer, to show the effects of impact on a surface of similar material, strikingly illustrates the origin of the moon's craters by impact. Since these laboratory "craters" are on a much smaller scale than their lunar counterparts, it is impossible to reproduce all the details of inner terracing, central cone, and complex wreath structure seen in the latter. However, the first and last features mentioned are closely approached in the experiment.

crater features described above are volcanic in origin; that the dark circular maria are the sterile beds of vanished seas, and that the "rays" emanating from certain craters are the effects of extrusion of light-colored lava from the interior of a primeval moon racked by tidal-stress. How far this view finds substantiation from physical and astronomic reasoning, or in what measure it avoids the difficulties which beset it, may presently become clear.

*Distribution.*—Doctor T. J. J. Sée of the Mare Island, California, Naval Observatory has recently completed certain revolutionary investigations in terrestrial physics which conclusively prove that the pressure of the oceans on their basins forces sea-water through crevices in their floors, and this water, coming into contact with superheated lava deposits located under the edge of the coastal crust, causes vast portions of the latter to subside. This unequal subsidence forces the underlying lava up under the continental borders, and the long-continued action of these disruptive processes rear the great terrestrial mountain chains and gives rise to volcanoes and earthquakes.[8] The Bogoslav Islands, which rose from the waters of the north Pacific—in the Aleutian Group—in September, 1907, is a striking illustration of these mighty world-modeling forces.

Applying Doctor Sée's theory of volcanic causation to the distribution of craters on the moon, we are confronted with the fact that the lunar "volcanoes" are most widespread where we should least anticipate their presence; *i.e.*, in the "great southwest" about the crater Tycho and in the smooth dark "maria," while in the proximity of the "sea-shores" they are relatively scarce. Such failure of expression on the ancient "sea-

*From *Popular Astronomy*.

[1] A. St. Clair Humphreys: Journ. British Astronomical Association, December, 1891, p. 132.

[2] J. B. Hannay: Nature, vol. 47, p. 7, (1892). Also Faye: Rev. Scientifique 27, p. 130, (1881). Also, H. Ebert: Anneln Physik und Chemie, vol. 41, p. 351 (1890).

[3] In art, "Tide," Encyclop. Brittan., V. xxvi, pp. 960-61. 11 ed.

[4] "The Moon": R. A. Proctor, London, 1873, p. 345.

[5] Belgravia, vol. 36, p. 153. (1878).

[6] "Newcomb's Astronomy": Simon Newcomb, New York, 1892, p. 320.

[7] "The Moon's Face": SCIENTIFIC AMERICAN SUPPL., vols. 36-37: pp. 14, 994-99; pp. 15,003-06; pp. 15,016-18. (Dec. 23-30, 1893 and Jan. 6, 1894.)

[8] "Researches on the Evolution of the Stellar Systems," vol. II, art. 169, pp. 352-54

borders" is due to lack of aqueous motive power, and is irreconcilable with the supposition that these reputed ancient seas once held water.

The late Professor N. S. Shaler of Harvard revived Robert Hooke's old theory—previously adverted to—and asserted that the lunar craters are the solidified remnants of bubbles which formed in a molten surface ages ago and subsequently burst.[9] Professor Shaler postulated the impact of meteors of planetoidal proportions for the genesis of the maria, but failed to recognize the community of origin with the craters evinced by the latter.

In view of the absence of any evidence of oceans or aqueous action in producing volcanic formations on the moon, are we not warranted in seeking further for a *vera causa* of the phenomena disclosed by the five-ninths of that orb which we are privileged to behold?

*Form.*—The predominant type of volcano on the earth is perhaps best represented by Vesuvius or Stromboli, the former shown in profile in Fig. 1. The Vesuvian crater is usually a lofty mountain, sloping gradually from its apex to a broad base, while the inner walls incline more abruptly to the crater floor within. The solid material extravasated from the vent of the volcano gradually builds up a cone several miles in height. The craters of Vesuvian volcanoes are small in comparison with the cone formed by the ejected lava, while the central hill, if present, is punctured at its summit by a vent. These volcanoes are violent and explosive during eruption, since their lava contains so large a proportion of water that its conversion into steam rends the ejecta into fragments and fine dust, the latter floating for many

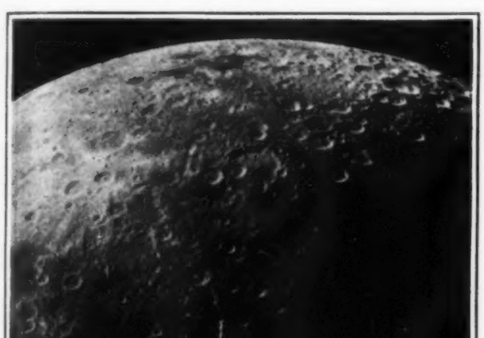


Fig. 6.—The Rheita Valley (0.9; 1.1); from a Lick negative. Note the peculiar southeasterly off-shot of this groove, due perhaps to deflection or diminished momentum of the graving matrix of rock borne across this region of the moon from the Mare Imbrium. A long, narrow valley is seen to extend from the western edge of Piccolomini (0.9; 0.6) southward and almost parallel to the Rheita Valley.

months in the upper reaches of the atmosphere, producing very satisfactory and brilliant sunset effects for the esthetically inclined.

Fig. 2 is an enlargement of the lunar crater Theophilus made from a Lick Observatory negative; this may probably be compared with the preceding cut of Vesuvius. The inner height of the cliffs of the lunar crater is over double and even treble that of the outer, while the basin of the crater is deeply sunk beneath the level of the outer plain. The diameter of Theophilus is about 64 miles, with a maximum depth from inner plain to the summit of about 18,000 feet.

A terrestrial contrast to this is afforded by the obelisk-like spine of viscid lava which rose from the caldera of Mont Pelée in May, 1903, to a height of 1,200 feet above the rim of the crater.

Finally, the rim of a Vesuvian crater is not developed into a complex wreathed and terraced structure as typified by Theophilus or Copernicus; it is devoid of the successive terraces on its inner slope, while the smooth inner plain of the lunar crater fails of any recognizable likeness to the rough disorder of the lava beds of Vesuvius and Krakatoa. Indeed, Professor Pickering states that "the features that are most prominent in our ordinary terrestrial volcanic regions are never seen upon the moon."[10]

The Hawaiian type of volcanoes, represented by Kilauea and Mauna Loa, are characterized by a low, nearly circular rampart containing a level expanse of solidified lava which slightly resembles the inner floors of Plato and Eratosthenes on the moon. The eruptions of these volcanoes do not liberate vast quantities of steam-gorged lava during that process; hence, eruption is only a quiet welling up and overflowing of the caldera. They slightly resemble lunar craters in that they exhibit inner plains, and a certain terracing of their inner walls is noticeable. Yet, the fact that the rims of the former are devoid of complex wreaths and "landslip" terraces and slopes and that none, save one or two, are exceptions to the universal law of elevated planes, and that the

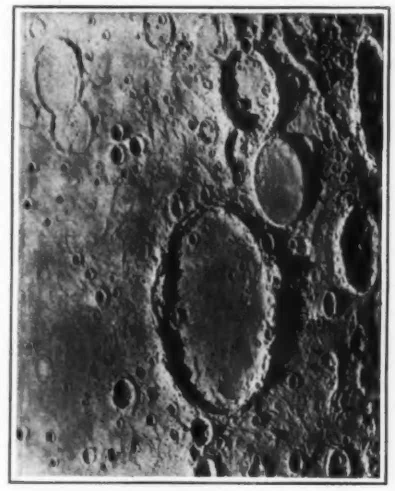


Fig. 5.—Enlargement on bromide paper of the plateau Wargentin (1.0; 0.8); from Nasmyth and Carpenter's "The Moon." To the south (or above) of Wargentin appears a similar elevated plateau, or crater filled almost to the level of its rim with molten lava splashed into it from the moonlet impact which created the Mare Imbrium.

central cone is absent, constitute the differences which far outweigh any fancied resemblance between the contrasted types.

*Origin.*—If we conceive the moon as an edifice which had its foundation in a ring or shoal of meteors encompassing the primeval earth, and similar to the giant planet Saturn (the meteoric constitution of whose rings was spectroscopically demonstrated by Keeler in 1895), and if we imagine this shoal gravitating together and building up our satellite by accretion, no violence is done the essential principles of Laplace's immortal Nebular Hypothesis. Meteors replace molecules, that is all, as long ago pointed out by the late C. A. Young.[11] The mechanical behavior of a meteor swarm containing individual masses and endowed with the ordinary velocities of meteors would be precisely similar to a nebulous mass of continuous gas.

The mathematical analysis of the mechanical conception of a Saturnian ring is not in place in a discussion of this nature, but by imparting to the postulated meteors in the swarm orbits not widely variant from that of the moon's, and in a similar direction, their initial velocities at impact were small as compared with those created by the moon alone. Since the course of these moonlets were parts of curved orbits with the moon at their focus, they cannot justly be considered as straight lines. By restricting these meteors to a thin plane ring, and assuming a fairly equable distribution through this plane, the distribution of impact angles deduced by Gilbert yields a curve in which 58 per cent deviate from the vertical less than 20°; 70 per cent less than 30°, while 80 per cent fall within 40° from the true vertical. To the vertical infalls consequent upon this condition is due the prevalent circularity of the craters and obviates a resort to R. A. Proctor's improbable suggestion of an elastic return to circularity.[12]

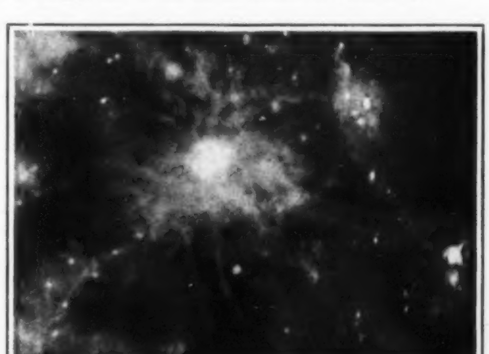


Fig. 8.—Copernicus (1.0; 1.1), Kepler (1.8; 1.4) and Aristarchus (2.3; 0.7); from a Goodsell Observatory negative. The systems of bright streaks radiating from the first two craters are due to the collision of moonlets containing considerable quantities of light-colored minerals. Professor Wood's photographs of the moon in ultra-violet light have revealed a large deposit of sulfur to the east of Aristarchus.

Laboratory experiments with a lead disk 5.5 inches in diameter and about 0.5 inch thick as a target, into which .22 caliber bullets of the same material were fired, demonstrate experimentally the effects produced by the impacting moonlets upon the moon's surface. Interesting replicas of the moons' crater forms were thus obtained by the writer, and are well shown in Fig. 3. Compare with the great pitted region of the moon shown in Fig. 4.

*Overlap.*—An instance in which a larger crater overlaps and partially obliterates an earlier and smaller formation is shown in Fig. 4, which is an enlargement of Maurolycus, in the roughest portion of the moon. The observed fact that there are comparatively few of these examples is eagerly taken by the volcanic advocates as proof positive that the moon's craters are defunct volcanic formations. But the very paucity of instances, far from proving the truth of the volcanist's contention, is mutely eloquent in our defense, since the probabilities would be overwhelmingly against the survival of this species of "overlap" crater. Yet this superposition of larger over smaller craters is exemplified by Longomontanus, Maurolycus, Hainzel, Schiller and others.

*Sculpture.*—The peculiar plateau of Wargentin and Phoclydes b, shown in Fig. 5, are striking examples—in more than one sense—of some tremendous lava deluge. The first-named object is a smooth, nearly circular *mesa* 54 miles across and filled nearly to the level of the lowest point of its rim with solidified lava. That Wargentin does not reign alone in his unique grandeur is proclaimed by the partial filling of Gassendi, Letronne and Hippalus to the north; craters which experienced

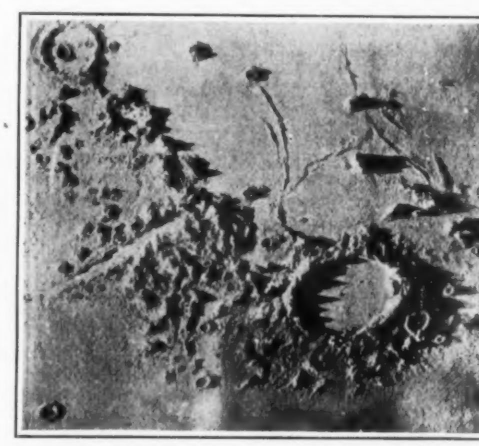


Fig. 7.—Valley of the Alps (0.5; 0.8); from Nasmyth and Carpenter's "The Moon." A good example of grooving by a moonlet striking a glancing blow.

a community of origin with Wargentin and the neighboring depressions.

As the result of moonlet impacts in the adjacent maria and the fall of lithic dust from their conflagrations, Boscovich is scarcely to be recognized as a crater, while Julius Caesar and Le Monnier have nearly lost their characters. To the vaporization of the more massive bodies the many "ghost craters" on the moon owe their partial effacement, typified by Fra Mauro, Fracastorius and Cassini. As Doctor Sée wrote concerning these dim specters of the desolate lunar Hades.[13] "So far as one can see, only two explanations are tenable: 1. The deposit of cosmical dust from the heavens, and from conflagrations arising in the impact of satellites. 2. The partial melting down of the walls by the conflagrations which produced the maria, so that only an outline of the original crater walls can be traced."

The southern boundaries of the great Imbrian lava deluge visioned forth as occurring far down the vista of the ages were determined by Pitatus and Hippalus, while southwestward the onslaught of the impacting planetoid's molten flood attained Posidonius, and eastward it lost itself in the Oceanus Procellarum. By this memorable worldwide cataclysm, which at one stroke wrought the Maria Imbrium, Nubium and Humorum and the encircling ramparts known as the Apennine and Caucasus ranges, "were introduced the features necessary to a broad classification of the lunar surface."

*Lunar "Valleys."*—A veritable "Valley of the Moon" is the Rhetia Valley, shown on the photo of the crescent moon, Fig. 6. This is a shallow groove of varying width with a shorter off-shoot on the south end. It runs from the eastern edge of the crater Rheita southwestward more than 185 miles to Rheitad; its breadth varies from 11 to 25 miles, with a maximum depth, according to Beer and Madler, of about 11,000 feet. A long, narrow cleft resembling a rill, starts from near Piccolomini and

[9] Cf. Smithsonian Contributions, 1903, part ii, pp. 103-13.
[10] "The Moon": W. H. Pickering; New York, 1903, p. 24.

[11] "General Astronomy": 1889. art. 526, p. 296. (Boston.)
[12] "The Moon": R. A. Proctor, p. 346.

[13] SCIENTIFIC AMERICAN SUPPL., vol. 69, p 204 (March 26, 1910)

trends southwestward more than 450 miles to near Metius, which temporarily interrupts it; but as shown in Fig. 6, it continues its course beyond that crater and to the right of the Rheita Valley.

However, the Alps Valley, Fig. 7, a straight defile traversing the lunar Alps range, is the most interesting of them all; betraying an exceptional character which demands for its origin an exceptional explanation. A trough-like flat bottomed groove trending east-northeast by west-southwest clean across the Alps range; it is 83 miles long by from three and one-half to six miles in width, and from its positioning bespeaks kinship to the Imbrian deluge, thus uniting the furrow group of the western district with the eastern sculpture system.

*Bright Rays.*—The system of brilliant rays which radiate from the crater Tycho down the lunar disk, like luminous parallels of longitude, and also the wavy streaks converging upon Copernicus; the lesser systems of Proclus, Kepler and Snellius, are the most enigmatic phenomena of the moon's surface. Those emanating from Tycho extend for vast distances across the lunar disk; in one instance—that of the one crossing the Mare Serenitatis—near 1,800 miles. Straight as the famed canals of the desert planet Mars, they seem not to mind obstructing craters or elevations in their pre-determined path. As a contrast, those radiating from Copernicus are branched and wavy and much shorter than the Tychonic phenomenon. The feathery tentacularity of the Copernican system is well shown in Fig. 8.

Most conspicuous at full moon, under the vertical solar illumination, they seem to be superficial color-streaks only, and one can be seen on the inner floor of Saussure, near Tycho, and may even be traced up its inner cliffs, like a vein of volcanic trap piercing sedimentary rock-strata on our own planet. This is a treacherous analogy, however, as Mr. R. S. Tozer has pointed out.[14] "The lowest visible stratum on the moon is dark, the configuration of the edges of the light-colored portion showing plainly that the darker portions extend underneath. . . . Whence, then, the light colored lava?

These brilliant rays cannot be inner material extruded from beneath a crust rent by tidal-stresses, since an exact restoration of level which would not cast shadows at sunrise or sunset along hundreds of miles would be practically impossible. But the suggestion advanced by Mr. William Wurdemann of Washington, D. C., seems more plausible; viz.,[15] that "a meteorite, striking the moon with great force, spattered some whitish material in various directions." Furthermore, Professor Gilbert, in the lecture previously adverted to, made the prophetic suggestion that "perhaps the free iron and nickel of meteorites may stand sponsor for free sulfur or phosphorus in moonlets."

This apparently unwarranted speculation of Gilbert's seems to have been verified by Professor R. S. Wood of Johns Hopkins University.[16] Twelve photographs taken by Professor Wood in ultra-violet light ($\lambda$ =3,000-3,250) revealed the existence of an extensive deposit of sulfur near and east of the famous crater Aristarchus (see Fig. 8), which is so refulgent that Sir William Herschel is reputed to have mistaken it for a volcano in eruption, when he observed it telescopically in the dark portion illumined only by the ruddy earthlight. These photographs, taken by means of ordinarily invisible light, throw a flood of light on one of the most obscure problems of our satellite's physical constitution. The moon was photographed with a quartz lens 4.7 inches in diameter, heavily coated with silver nitrate. Letters painted by Professor Wood on a magazine cover with zinc oxide (Chinese white) came out jet black in the photograph.

*Summary.*—The foregoing cursory discussion of the moonlet impact doctrine, adhering to purely physical lines of reasoning, has revealed an hypothesis which logically and comprehensively illuminates the varied and obscure phenomena of our satellite, the moon, and reconciles theory with the details revealed by the telescope. As Professor Gilbert fittingly remarked:[17] "The impact theory applies a single process to the entire series, correlating size variation with form variation in a rational way. It brings to light the history of a great cataclysm, whose results include the remodeling of vast areas, the flooding of crater cups, the formation of irregular maria and the conversion of mere cracks to rills with flat bottoms. . . In fine, it unites and organizes as a rational and coherent whole the varied strange appearances whose assemblage on our neighbor's face cannot have been fortuitous."

Through the inconceivably gradual process of accretion the substances which were busied to form the moon's mass did not undergo fusion. Consequently, the motive force for the initiation of volcanic processes was never present in our satellite. And even had molten lava underlain the lunar crust, the absence there of seas in the dark maria went bail for the immunity of the moon against the ravages of volcanic fury.

A larger orb, such as the earth and the major planets, passes through epochs in its evolution from a widely diffused gas or a meteor swarm to a cold, inert cinder which smaller orbs, by reason of the paucity of their masses and relatively greater surface, may never know. The nascent moon must have attained and passed her heat-acme when materially less massive than now; yet even so, she was darkly cold from center to circumference. She was destined to remain cold and meteoric from first to last, experiencing none of the varied states through which Jupiter or Saturn passes. In this connection it is pertinent to consider the late lamented Doctor Percival Lowell's remarks on the possibility of past volcanic action on the moon as follows:[18] "On the principle that the heat to cause contraction was as the body's mass, this state of things on the surface of our satellite is unaccountable. The moon should have a surface like a frozen sea, and it shows one that surpasses the earth's in shagginess." He then proceeds to evaluate the internal heat (or rather the lack of it) generated by the moon through accretion. This, he shows, could not have exceeded 450° absolute, which reduced to Fahrenheit scale, reads—9° F. "To point out that any volcanic action could be produced by this quantum of heat is superfluous," he adds significantly.

In the Saturnian ring postulated above, the earth was once surrounded by a shoal of discrete meteoric bodies of varied masses, which suffered perturbations destructive to its stability. Doubtless many centers of aggregation formed in the disintegrating pre-lunar ring; since were the moon the only center, the scars produced by the subsequent impacts would all be small. As heretofore stated, this view is not opposed to Laplace's Nebular Hypothesis, since Professor Sir G. H. Darwin demonstrated mathematically that a cloud or ring of meteoric bodies behaves substantially like a gas. Since, according to the kinetic theory of gases a gas is merely a swarm of separate molecules, the distinction is one of mass only, and does not invalidate Laplace's majestic conception of the annulation of a contracting nebulous mass. As Professor Sir G. H. Darwin fittingly remarked:[19] "I believe that the theory I have just explained (meteoric) as well as the theory to which I am coming (Laplace's) contain essential elements of truth, and that the apparent discordances will someday be reconciled."

Thus meteors, or rather moonlets, act as protagonist to the solution of the lunar enigma; Rosetta stones by which we may comprehensively decipher the age-old lunar hieroglyphic and evoke a clear conception of what went before our tardy advent upon the scene of things Cosmic.

In that remote eon when the earth was racked by the volcanic tumult of her early geologic birth, the moon was bombarded and gashed by colossal meteoric missiles from the sky; everlastingly sealing her doom as the abode of intelligent life. Thus is strikingly exemplified in the broad field of Cosmic phenomena the cornerstone of the Darwinian doctrine: "Those species which possess a sufficient measure of adaptation to their environment survive: those which fail to so adapt themselves must perish." In astronomy this inexorable decree of evolution finds its noblest application to that pale, mysterious sisterworld of earth's which every twenty-four hours upheaves the mighty deep in its tidal swell and renders less profound the otherwise Stygian gloom of night.

And unto this day she rides the courses of the nocturnal firmament, "with white fire laden," a sterile wanderer whose rocky desolations never woke to the Creator's highest gift to our world—*Life.* As expressed in the fitting eloquence of Scripture:

"For it shall be established for ever as the moon,
"And as a faithful witness in heaven";
—Psalms, 89: 37.

## Dielectrics in Electrostatic Fields

The problem whether dielectrics will change their dimensions when exposed to strong electrostatic fields, has received little experimental investigation. One would expect some change, although not more than a small change probably. Righi and Quincke made some experiments thirty years ago, and Cantone and Pozzani followed the matter up in 1900; but the results were not concordant. Resuming these investigations recently, L. Bouchet (*Comptes Rendus de l'Academie des Sciences,* August 17th and October 30th, 1916) first studied the expansion in a direction normal to the electric field. He placed cylinders of glass, paraffin or ebonite between two concentric cylinders of brass, filling the annular space left with water; the system formed a tubular condenser. On the top of the cylinder of the dielectric material he placed a glass plate, and on this a lens; when the electric field was excited by an influence machine (Voss) the cylinder expanded in the direction normal to the electric field and pressed the glass plate against the lens, causing displacement of the interference rings. The length of the cylinders was about 40 cm., the diameter 1.5 cm., the thickness up to 2 mm. The expected dilatations were observed, but they amounted to 1 part in $10^{10}$ or less. The expansion was proportional to 1/E, however, E being the Young modulus of elasticity, an interesting relation. On the other hand, the numerical results were not what they should have been for perfect dielectrics, and glass and ebonite (half-hard), which disagreed most, are, indeed, far from being considered perfect dielectrics. There seemed to be no direct external electrostatic pressure effect on the length of the insulator. In the second series of experiments Bouchet studied the effect of the electric field in the direction of the electric lines of force. The electrostatic pressure effect would probably be more marked in this case, and there might be superposed either a contraction or a dilatation of the dielectric owing to the internal stress. The materials chosen for these experiments were pure Para rubber, vulcanized or unvulcanized, and, further, glass. Discs were formed, 15 cm. in diameter, up to 0.65 cm. in thickness, and stuck (with paraffin) to discs of brass; on the top of each disc was placed a piece of aluminium or tinfoil, the brass and foil thus forming the condenser electrodes. Changes in the thickness of the disc were again measured by the method of interference. In the case of the vulcanized rubber the observed contraction (amounting to $22\times10^{-6}$ cm. maximum) was somewhat larger (although less than 100 per cent larger, certainly) than the calculated contraction, and increased with the square of the field intensity; the unvulcanized rubber seemed to conduct the current and behaved less satisfactorily. In order to ascertain whether the direct electrostatic pressure (attraction between the top and bottom of the condenser) was an important factor, Bouchet piled five of the vulcanized rubber condensers upon the top of one another, to form a multiple condenser; in that case the direct attraction effect should be the same as in a simple condenser, because the attractions upwards and downward would balance one another in the intermediate condensers (of the multiple arrangement). The observed contractions were double those of the experiments with the simple condenser. Thus the contraction due to the internal electric stress would appear to be much stronger than the direct pressure effect.—*Engineering.*

## Blowing and Breathing Wells

What are known as blowing wells are described by the United States Geological Survey, Department of the Interior, in a recent letter to a correspondent.

"Blowing" wells, also known as "breathing," "sucking," "weather," and "barometer" wells, it is stated have been reported from many localities. When such wells have been carefully observed it has been found that the blowing and sucking occur alternately—that is, at certain times the blowing is outward and at intervening periods it is inward. It has been found that the phenomena are due to differences in atmospheric or barometric pressure. The necessary conditions seem to be a porous stratum, such as sandstone, gravel, or porous limestone, only partially saturated with water, overlain by some impervious substance such as shale or clay. While the atmospheric pressure is high the air enters the well and collects in the upper part of the porous stratum above the water level. While the barometric pressure is low the air is expelled with considerable force, producing what is known as "blowing." This blowing frequently occurs during storm periods or when the wind is in a certain direction or during certain periods of the day.

"The peculiar action which you have observed in the case of your own well may be due to causes similar to those above mentioned. If gas is escaping it ought not to be difficult to detect its presence. It should first be tested to see whether or not it will burn, and for this test a funnel or some other contrivance can be used. In case it will burn it may be either marsh gas or 'oil or rock gas.' Whether it is one or the other can be determined with some probability, though not with certainty, by chemical analysis. Some natural rock has almost, if not exactly, the same composition as marsh gas.

"It is not at all probable that your well is giving off gas in sufficient quantity to be used for domestic purposes, but in case it is it will be necessary to install some mechanical device for collecting and storing the gas. From the storage tank it could then be piped to your residence to be used as fuel or light."

[14] "The Mountains of the Moon," Scientific American Suppl. Vol. 59, p. 24,632. (June 17, 1905).

[15] From a letter to Dr. B. A. Gould on the origin of lunar topography.

[16] Scientific American Suppl., vol. 70, p. 125. (August 20th, 1910).

[17] Scientific American Suppl., vol. 37, p. 15,017. (Jan. 6, 1894)

[18] "Mars as the Abode of Life": Percival Lowell, 1908, pp. 23-24.

[19] Address before the British Association for the Advancement of Science, South Africa. March, 1904

## The Indian Silk Industry*

By Professor H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S.
Imperial College of Science and Technology, South Kensington

In the time available today it is not possible to deal with an industry so large, so scattered, so varied, as the silk industry in India. In the report prepared by Mr. Ansorge and myself the full details of the industry are recorded, and this report will shortly be available. This afternoon I propose to describe very briefly the general conditions of the industry, to state its extent, and to enable you to see whether India can ever be a large source of supply of silk raw products to this country.

There are in India four kinds of silkworm; that feeding on mulberry, which is the usual silk of commerce; the tasar and muga, wild silks which resemble shantung; and the unique eri, the domesticated castor-feeding silk. Of the mulberry there are two descriptions, the single-brooded race, grown in Kashmir and the Punjab, from French and Italian seed; the many brooded races of Bengal, Mysore, Assam, Burma. Both are reelable and yield two products, raw silk and waste silk; but the quality of the products of the French cocoon is far superior to that of Bengal and Mysore cocoons, and their uses in trade are quite distinct. So are the conditions of their production: the largest industry is concerned with the production of the many-brooded races in Mysore and Bengal; the worms are reared in the people's houses, fed with leaf plucked from the fields; the cocoons are spun on trays and are killed by the sun's heat; the reeling is done on a primitive apparatus over a fire, usually two threads at a time, and yielding an uneven coarse thread, little appreciated outside India. In Mysore the silk produced is woven locally, or in the Madras weaving centers; of the Bengal silk much is used in Bengal, Nagpur, Amritsar, etc., but much is exported, chiefly the product of the filatures of which a few remain, still under the control of a European firm. The Assam and Burma silk is locally used in weaving; it is not a large amount, and is grown wholly for home consumption. This silk is from worms fed entirely on mulberry grown as a field crop as bushes. The superior French race, grown in Kashmir and the Punjab is fed on the leaves of tree-mulberry, and the industry owes its existence to the fact that, in Kashmir, mulberry grows wild all over the valley. There, too, the people grow the worms in their houses; but the cocoons they deliver to the State, and the reeling is wholly done at a central filature. In the Punjab the little silk produced is sold for reeling at Amritsar or sent to Bengal for reeling.

Tasar is wholly a wild insect, which inhabits a great part of the hilly, jungly areas, centering in the great Chota Nagpur and Orissa Forests. In this area it is abundant enough to be worth collecting, and there are classes of people, of hill tribes, who add to their earnings by putting worms out on trees and guarding them. The production is an ancient industry, formerly supplying local needs, furnishing an article for barter with cultivating villages near jungle tracts, who used the silk. And it is an industry that has altered much as the forest areas have been controlled and exploited. As the country opens up the industry naturally declines; the cattle-herds who collect the cocoons, the tribes who rear them, find cultivation or field labor safer and more profitable. The production of tasar is connected with restrictions in food, tobacco and other enjoyments, which are irksome. Disease in the worms is uncontrollable and often disastrous.

So the tasar-producing industry lessens, and will decline unless science can be applied, can combat disease, can make the crop sure and a large one. There are peculiar difficulties, both scientific and other, in this question, and it is not certain that there is justification for the cost of tackling them.

Muga is a similar insect, feeding on other plants than mulberry, and found only in Assam; it is grown similarly and used similarly. There is little use for it outside Assam, and the bulk is locally used.

Some years ago the question of eri growing outside Assam was taken up. The industry was started in many parts of India. A mill in Bombay bought cocoons and spun them into yarn, which is still used in Benares and Bhagalpur; but the effort has failed, and eri is now practically confined to Assam as before.

The production of cocoons and silk is largely a subsidiary industry to cultivation; it is a cottage industry, yielding from ten to three hundred rupees a year to the family who practise it; it engages as rearers and reelers some 400,000 people; it is limited to very definite areas, some of which are decreasing in extent. There are in India some 300 million people, chiefly cultivators; of these one in a thousand adds to his earnings by growing mulberry or castor for feeding silkworms—why do not more do it?

There are definite factors which affect this. They are—climate, custom, prices, disease, ignorance. As regards climate, silkworms, to be profitably grown, must have the right climate; and this climate must persist long enough to feed a brood of worms, say, for two months at a time. In Kashmir they get one crop in May, June; before that it is too cold, after that there is no leaf, and later it gets too cold. In the Punjab there is one crop in February-March; before that it is too cold, after that it is too hot. In Bengal the best crops are in October-November, February-March; at other times it is too cold, too hot, or too moist. So for all India one can determine exactly when conditions are right or wrong, and areas where silk is produced are those where conditions are right.

Secondly, custom—by that I mean the practices of the people, dictated by religion. Many classes will not do silkworm-growing as it entails killing the chrysalides. In Assam and Burma those who do it are generally looked down upon; in the United Provinces, for instance, the largely-predominant Hindu population would not do it. In Travancore, the lower castes and Christians may take to it, but no one else will. Those of you who know India will understand; those who do not must try to realize it. Just as you cannot produce an unlimited amount of long-staple cotton in India because of the insect pests, so you cannot grow unlimited silk because of custom. People in England find it difficult to realize this.

The third factor is price. The silk production of Bengal is probably now less than a tenth of what it was forty years ago, because the prices of rice and jute have gone up steadily, and the price of silk has remained steady or fallen. A pound of silk was equal to 120 seers (220 lb.) of rice thirty years ago, but is only equal to forty now. And as the rearer eats rice he has, wherever possible, abandoned silk: he is better off, and we need not regret him.

Fourthly, there is in all silkworms a disease called pebrine and others called flacherie, grasserie, etc. The first appeared about 1875 in India, and has done great harm; we have treated it on European methods which we now find do not apply in India. Much money has been wasted in Bengal with no effect, and we have now to tackle it properly or see the industry decline.

Lastly, ignorance. There are many places in India where silkworms will grow, but no one knows when or how; but they try, fail and give it up. Many native States have tried and failed; and it is probably only now that we realize exactly what must first be learnt before we can start growing silkworms in a new area. When we have skilled people who can say exactly when and how silkworms can be grown, then silk will be grown in new areas suited to it.

We will now turn to the fascinating aspect of the working up of the silk. First, the raw silk is taken as it is bought in skeins and is opened out; it is then placed over a swift or over two bamboos or three upright rods, and is wound off on to bamboo reels; as the thread passes through the fingers its thickness is estimated and it is sorted into four qualities—the finest goes to one reel, the medium to another, the coarse to a third; the very coarse is rejected. Each quality has its uses, and for this reason the Indian likes and buys coarse Indian or China silk, because in the one skein he gets the qualities he needs for weft and for warp.

Each quality is then tested for its proper use: the warp is usually twisted, first each thread singly, then two together for the best warp. I illustrate a variety of methods by which this is done; they vary in mechanical perfection from the very slow, crude, single-thread process to the machine doing forty threads at a time. This work is all done by special workers, men or women, in the weavers' quarters or the village.

After twisting comes degumming, dyeing, rewinding and warping. All are done in the houses with simple devices; the warping may be done in the open, on upright sticks, or over pegs on a board, or on a revolving mill from a creel of bobbins. There are all degrees of method. The warp is then laid out, brushed and the healds knitted on by a special worker. In some cases they use eyed healds and the thread is drawn in. The thread is then drawn through the reed, and fixed to the beam of the loom.

Looms vary greatly in type, and there is in India an enormous variety of method, from the simple loom with two shafts to the exceedingly complex *kamkhwdb* loom, weaving elaborate brocades.

The object of the weaver is to secure variety of texture and pattern; he can do this by five methods—actual weaving, *i.e.*, methods of so arranging the warp threads that he can produce a texture or pattern; arrangement of differently colored warp and weft threads, so that he gets a pattern; arrangement of variegated warp or weft threads dyed in sections, giving pattern; additional pattern by embroidery or by shuttle embroidery, as in tapestry weaving; dyeing or printing after weaving. The Indian craftsman uses all five methods separately or together; and there is a very great variety of fabrics produced, from plain white silk to the elaborate and beautiful *kamkhwdbs* worn by princes.

It is impossible here to describe the methods used, all contrived with extremely simple devices; the simplest loom has two shafts, two pedals, and pattern is only possible in stripes and checks. Then there is the four or many-shafted loom, weaving twills and twill patterns. In Burma this leads to the eight- and twelve-shaft loom doing beautiful fabrics. Then there is the loom with the shafts replaced by cords, and varying combinations of cords worked by strings; there is the Dobbie, used chiefly for borders; and there is the elaborate loom in which each pair or set of threads is connected to a string, and combinations of these are pulled in turn by a boy, who picks them out by means of a series of loops put round each consecutive combination by the loom-setter. This method will give any elaborate combination required; when to it is added the complexity of separate border warps and border shuttles, of separate workers putting in embroidery with shuttles, you get the gorgeous and elaborate *kamkhwdb*.

There are other fabrics made by tying up the warp threads, dyeing the untied parts, and then so arranging them to make patterns; and this is a common device in India. Beyond this are the lovely embroidered fabrics of North India embroidered in floss silk or in heavy thread in a peculiar knot stitch; in these there is great artistic scope and full advantage is taken of it. I show you a few of the fabrics so made, only a very small number that attracted me specially; but the variety of design and texture in India is amazing.

The silk-weaving industry of India is large; it employs probably 200,000 people as weavers and 100,000 as twisters, preparers, etc. In the main the industry exists to supply the silk fabrics of the country, and in this there are three principal classes—the silk *sari*, *dhoti*, and conventional dress prescribed by custom; the embroidered and fancy silk article mainly made in North India; the fancy silk piece made for wear in Burma, in which variety of design is the essential qualification.

The first is the backbone of the industry. In the Bombay Presidency, Madras, Mysore, Bengal, the Punjab, Nagpur, and Benares there is a weaving industry turning out goods of great value in the conventional garment of the Hindu. This absorbs much Indian silk and more imported silk. The articles are not piece-goods, but complete pieces ready to wear and in all qualities, from silk-bordered cotton to *saris* costing up to £20 a yard. The value of the cloths so produced, taking an average value of cloth as double that of raw silk, is near to £2,500,000; and it is on this demand, little influenced from without, that the industry mainly depends.

There is secondly, the large trade in fancy silk goods, ribbons, fringes, ornaments, huqa tubes, and embroidered goods, made chiefly in North India. There is no means of estimating even approximately its extent or value.

Thirdly, there is the special market of Burma, which imports yearly raw China silk worth £140,000 and weaves cloth, but it also imports cloth worth £250,000 and wears it. The Burmese are peculiar in that they buy variety, not fixed patterns; they need bright colors, pink, yellow, and mauve in patterns and, above all, variety; so Japan and India export to Burma a great variety of piece-goods which make into *longyis* and *pasos* for daily wear. There is a remarkable industry in Rangoon in printing patterns from wood blocks on Japanese silk; the Burmese in this way get variety at a small cost and can get new patterns printed on whenever they tire of the old.

You will notice that I say nothing of ordinary piece-goods, of plain silks, of tabbys, satins, twills, suitings, spot and stripe silks, lining silks, and so on. There is a production for the big cities, but it is small, and nearly all that is sold is from Japan and China. The Indian craftsman can produce almost anything; in Madras and Burma he is learning new methods and producing new fabrics; but the home demand is so stable, so vast, so near at hand that the trade is mainly concerned with that. The export of Bengal corahs, plain silk woven in the gum from untwisted threads, is nearly dead, and there is not much now produced in India that would interest this country.

*An abstract from a paper read before the Royal Society of Arts.

## Cost in Cement Manufacture

The cost of power required in the manufacture of Portland cement reaches a higher percentage of the total cost of production than in most any other industry. Investigations seem to show that, when properly operated, there is little difference in the power required by different types of machines used in the processes. Any reduction in the costs must be in the direction of the power used, and it is believed that electric power will materially reduce the expense of manufacture.


A mounted specimen in the National Museum, with natural surroundings


Photo by National Museum

Manikin of Roosevelt giraffe being assembled, showing struts and reinforcements inside

# The Art of Modern Taxidermy

## Realistic Methods of Mounting Animals for Museums

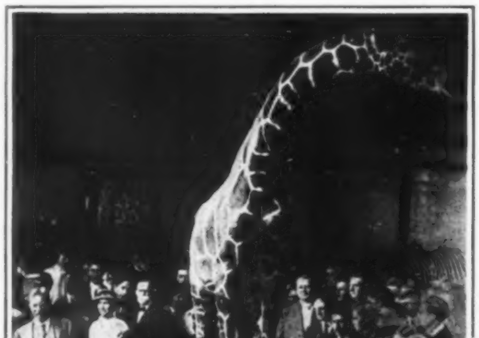
By Carl Hawes Butman

If you have visited a natural history museum lately and viewed the big game animals or the larger mammals, you have probably wondered how the mounted skins were made to appear so realistic. Several hundred thousand other museum visitors also marvel at the so-called "stuffed animals," which, by the way, they are not.

Modern taxidermists are not upholsterers but scientific sculptors. For several years taxidermists, in their treatment of the larger mammals at least, have been constructing hollow, reinforced plaster casts which prove not only light and durable, but far more realistic than the old forms stuffed with excelsior, cotton and sawdust, the wooden frames covered with clay or plaster which superseded them, or the papier mache figures of a little later date. The last mentioned are still used to a certain extent especially in Europe.

To comprehend the feats accomplished in the taxidermy shops today, one must first start with the treatment of the skin itself. Ordinarily when the animal skin is collected for mounting it is removed scientifically, care being taken not to injure it, and only certain necessary cuts being made. In removing the ordinary flat skin, a cut is usually made down the belly, running from the breast to the end of the tail. From this primary cut, other cuts extend down the insides of the legs, so that when the skin is removed it will lie flat like a rug. In special cases the belly only is cut, the skin on the legs being left much like sleeves; in the same manner, the skin of the neck is left whole. This style of skin is called a case-skin, and although a little harder to mount, appears more natural and shows scarcely any sewing, eliminating many seams on short-haired animals.

The skin, together with such bones as were collected, comes to the taxidermist cleaned and tanned. The more bones given him, the greater is his accuracy in modeling the form in clay. Usually the skull, with the horns, if the animal possesses such, and as much as possible of the skeleton is secured by scientists when collecting specimens for mounting, but it is often necessary for the taxidermist to work without the bones of the animal. He may have a live or a mounted animal, or perhaps a life cast to go by, or the bones of one of the same species from which he can secure data to scale down or up to his specimen. But when he has no bones or other material to follow, he has to measure the skin and calculate the animal's dimensions as best he can, relying on photographs, field measurements and notes made by the collector, and his own knowledge of anatomy.


Harris & Ewing, Washington, D. C.

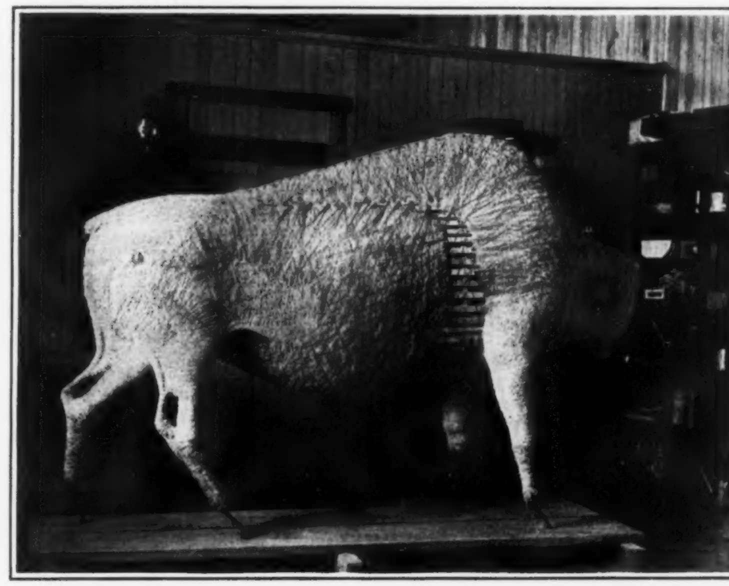
Mr. Roosevelt inspecting his mounted giraffe

There are six distinct steps in mounting a large animal skin, such as that of a lion, deer, zebra or other similarly coated mammal: the making of the minature, the full-sized frame work, the large model in clay, the mould, the cast and the applying of the skin.

After trying out several poses the taxidermist makes a clay miniature and then begins the full-sized clay model. Opinions of specialists differ as to the best procedure in modeling; some believe in the utilization of certain bones in building the framework for the figure, and others maintaining that the bones should be measured and studied, and the frame work made of iron rods and pieces of board. In either case, a rough framework is constructed and the modeling clay is applied. The taxidermist now works much as does a sculptor; adding clay here and removing it there, taking great care to reproduce accurately every joint and muscle, until he perfects a replica of the skinned animal.

The clay model completed, a plaster-of-Paris mould is built around it in several pieces. The plaster is applied in the usual way but is reinforced with rods to keep it from warping or falling apart when the modeling clay is removed. Here again each taxidermist has his own system of making moulds, but they all follow a general scheme. The mould is not often made in one or two pieces but is composed of many sections. In making the figure of a small deer, for example, the mould would be divided into twelve or fourteen pieces, but for a giraffe perhaps as many as fifty or sixty would be required. The main piece of the mould, called the "foundation," includes the under parts of the animal's body and the insides of its legs. Four pieces form the outsides of the legs, while several others cover its back, the top of its

Photos by National Museum
**National Museum taxidermy shops. One figure of Roosevelt lion group in foreground**



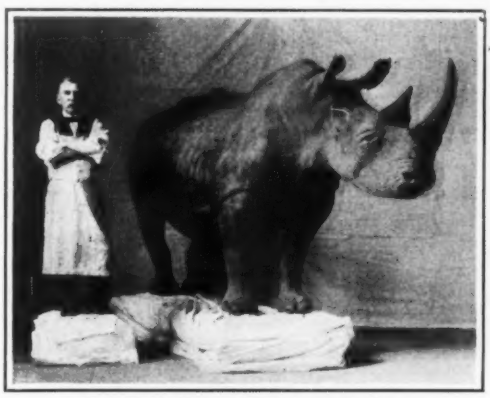
**Old style of mounting skins on excelsior padded frames bound with twine**

neck and head, boxing in the whole model. In making the separate sections of the mould, strips of tin or thin layers of clay are placed along the intersections, which are trimmed and oiled before the adjoining pieces are applied. The mould varies in thickness with respect to its size; for a medium-sized deer it would be about an inch thick. When it is thoroughly set, the pieces are separated at the intersections and taken off the clay model. Each one is smoothed up and retouched inside with fresh plaster wherever necessary. They are then assembled and all the edges made to fit snugly, so that the corresponding ones of the cast about to be made will meet properly.

The "manikin" as the completed figure is called, is not cast solid in one piece; but in thin reinforced sections, one from each piece of the mould; outer surface and boundary lines of every piece conforming exactly with those of its pattern. Selecting a section of the mould, the taxidermist cuts out a piece of sheeting to fit and sticks it with flour paste or glue, so that it assumes the exact contour of the inside, which will be the outside of the finished cast. Any depression neglected in this process would fail to reproduce its corresponding projection on the exterior of the complete form. This is especially so in making "manikins" for smooth-haired skins. Since a very smooth exterior is necessary, heavy sheeting is used, but for rougher haired animals burlap is equally serviceable. The cloth is first painted with a thin wash of plaster, and then reinforced by additional layers of burlap, saturated with plaster. When completed the result is a thin shell of cloth and plaster from one-quarter to three-eights of an inch in thickness, according to the size of the animal. Wire cloth is used by some taxidermists in place of the burlap. In this manner a section is cast from the inside of each piece of the mould, and when set, the newly cast sections are wet to dissolve the glue and removed from the moulds. The "foundation" cannot be taken out, so the mould is broken from the cast.

All the taxidermist has to do now is to fit the various pieces together and cement them with plaster; all the seams are covered on the inside with patches of burlap soaked in plaster. Braces of wood for reïnforcement are placed within the figures as the work of assembling progresses. One small section, usually in the back near one hip, is left out for a handhold and through this opening a wire tail wrapped in hemp is fastened to one of the braces. This opening also serves for the admission of air to insure a thorough drying. After the whole figure is retouched and shellaced, it is ready for the skin which is usually wet with water and poisoned to keep out insects.

When applying flat skins the animal is first covered with glue or shellac, then the skin is laid on and the seams sewed tight. If case skins are used they are as a rule pulled on over the hind legs like a pair of trousers and stretched forward over the back. The forelegs and head are cut from the cast and thrust into the skin, being attached later to the body with especially fitted locks. With hornless animals, the skin is pulled over the head and sewed neatly where it is cut, but if the animal has horns a little more work is necessary. Horns are left on the skull, a small portion of the crown of which is sawed off and slipped through the "Y"-shaped cut in skin of the head, where it is attached by screws to a block of wood set in the head of the figure. The animal's ears are left attached to the skin and when the cartilege is removed, exact counterparts made of sheet lead are inserted and fixed at the proper points of the head. The hoofs or claws are modeled or filled out with clay where they are fitted to the plaster legs. Painted glass eyes are set into the sockets, where they are moved about until the proper line of vision is secured.



**One of Heller's white rhinos, in the National Museum**

When the skin is sewed securely together, it must be made to fit snugly in the hollows, and this is accomplished by tacking it down with strips of cardboard or pieces of light rope which are left in place until the skin is stuck to the form. The hair is combed and brushed carefully, especially over the seams, so that it will look as natural as possible. Parts of the nose, mouth and eyelids are

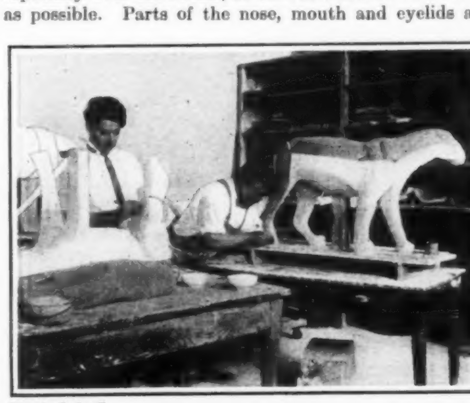


Photo by Rockwell
**Building a mould around clay model of a leopard (right); working on a cast in its mould (left)**

usually retouched and stained to represent their natural colors.

In preparing casts of the thick skinned animals like the elephant, rhino and hippo, a similar process is followed, but the skins are usually put on dry to prevent their cracking and to insure a durable result.

Smaller animals, such as squirrels, rats, etc., which have longer hair and can be handled easily, are still mounted in the older manner by using wireframes padded with cut excelsior and wrapped tightly with twine. Very lifelike replicas are produced by this method, which is the only practical one for small animals, and much less expensive than the plaster casting system.

All has now been described as far as the animal itself goes, but much of the general effect of the exhibit depends upon the natural grouping, the groundwork or base and the trimmings of the case. Museums now endeavor to educate the public a little further in zoölogy. In the groups particularly, naturalness is the keynote and an actual scene depicting some phase of the animal's daily life is often shown.

Remarkable headway in producing natural environments for animal groups has been achieved during the last few years. When the scientists of the Smithsonian African Expedition returned from the field, they brought not only a general collection of animal skins and skeletons, but bushes, grasses and soil for use in finishing the bases of the groups. In both the harte-beast and water buffalo groups, for example, real earth, brush and grass was used in the groundwork, and the museum visitor now sees these families as they actually appeared on their native heath.

The National Museum elk group, constructed especially for the Panama-Pacific Exposition, was collected and built by Mr. James Clark, of New York, who went to the Yellowstone National Park for the three representative specimens. Besides the animals, he brought back parts of two fir trees which now appear in the case. If it had been possible he would also have secured snow to perfect his winter setting, but that had to be reproduced with white paraffine and ground glass. The result shows a typical winter scene which has won the approval of all who have seen it, and incidentally a gold medal from the Exposition Board.

Some museums exhibit their mounted animals in cases backed up with painted scenery which blends with the real settings, foliage, groundwork, etc. Viewed from the front the animals seem to be living in their native land. This gives not only an artistic but an instructive and interesting picture. In the National Museum, however, most of the cases are left open on four sides so that there is practically no front. A visitor may walk around the case and observe the animals from every quarter. This enables him to secure a better idea of the animals themselves, presenting many pictures instead of only one. Although there is no distant scene or background, the bushes, trees, etc., give a most realistic representation of the animal's habitat.

Among the well-known animal groups in the country are the Roosevelt lions, the zebras and oryx, and the water-buffaloes in the National Museum, all of which were made in the Museum shops by George B. Turner, of Washington.

## A Convenient Battery Cell Tester

The *Engineer* thus describes a convenient little battery cell tester for use in field telephone work. The device consists of a small flat pocket box with compass galvanometer, buzzer, and three-contact slide switch. The galvanometer shows the condition of the cell and the direction of the current. By means of the buzzer the strength of the cell can be tested. Putting on the buzzer by the switch produces a loud humming sound if the cell is in perfectly good order. Should the buzzer give no sound the cell is to be condemned as useless. It takes but a few seconds to test a cell.

# The Electrical Properties of Gases—I.*

## Which Enable Important Problems in Physics to be Studied

By Sir J. J. Thomson, O.M., P.R.S.

I

In opening his lecture Sir Joseph Thomson said that if the measure of the importance of a scientific subject lay in its power to come to close quarters with the fundamental bases of physics and chemistry, then the subject he had chosen for his course had strong claims to be counted as one of the most important in the whole range of physics. He would justify this claim by anticipating a little certain results, to be established later on. Two of the most fundamental questions of physics were: what was the nature of electricity? and what was the structure of matter? Now the study of the discharge of electricity through gases was responsible for the view now taken as to the nature of electricity. We now knew that electricity was, so to speak, atomic in structure, that every charge of electricity was made up of an immense number of smaller unit charges, and we differentiated sharply between positive and negative electricity. We knew that the atoms of negative electricity were extremely minute, having a mass less than anything else known up till a few years ago. They had, moreover, the power of moving with velocities which fell but a small percentage below those of light. The positive units were much more massive, having 1,700 times more mass than the negative particles. This view had been arrived at by the study of the electric properties of gases.

As for the other problem, concerning the structure of matter, the same study had shown that beyond the chemical atoms which made up the mass of ordinary bodies still smaller systems existed, each chemical atom being a little universe comprising many planets and suns. We knew that some of these atomic constituents were particles of negative electricity and we could count the number in any atom. In addition to these very small negative particles there was an equivalent amount of positive electricity. Moreover, by methods which the electrical properties of gases put at our service we could determine the magnitude of the systems inside the atom with an accuracy approaching that with which we could measure the size of ordinary bodies.

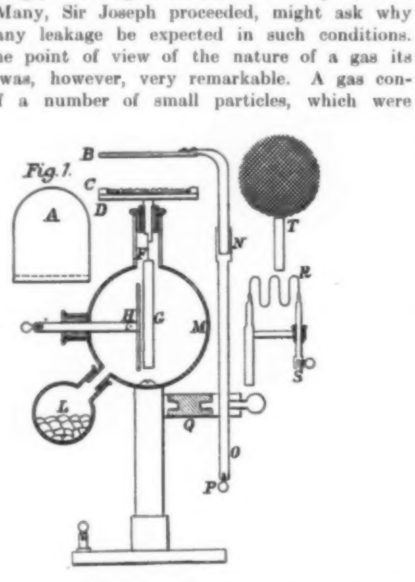
The study of the discharge of electricity through gases would, the speaker, proceeded, enable us to investigate problems of the greatest interest to the chemist. We wanted to know whether all the atoms of what chemistry recognized as elements were of the same kind. The evidence was that two atoms might show the same chemical properties and yet not be identical. One might, in fact, be more massive than the other. Since, however, the chemical properties were identical, it was impossible to separate the two by any chemical process. Hence in ordinary determinations of atomic weights we were not able to say whether we were dealing with anything but a mixture of two kinds of atom, although the weight of the one might not be the same as that of the other. The numbers given for the atomic weights might thus be vitiated by the fact that though similar in chemical properties the two were not identical as to mass. A sort of mean of the two atomic weights would thus be obtained.

An important question, raised long ago by Prout, was whether all the atomic weights were multiples of that of hydrogen. In the course of these lectures reason would be shown for believing that Prout was not very far wrong, after all, if we gave a wider interpretation to what he meant by the hydrogen atom. It was of course impossible to maintain this if the experiments on atomic weights were interpreted in the most straightforward way. The values found were certainly not integral multiples of the atomic weight of hydrogen. If, however, two atoms, chemically indistinguishable, had atomic weights of two and three respectively, a mixture of them might give an apparent atomic weight of anything whatever between the numbers two and three. Yet, nevertheless, the mixture would consist of units each an integral multiple of the mass of the hydrogen atom. It seemed possible, though in these strenuous times opportunity for proof had been lacking, that by a study of the electrical properties of gases new light might be thrown on this question of atomic weights.

In the foregoing he had, he hoped, said enough to justify the importance of his subject, and he would now show a few experiments. The first was perhaps hardly an experiment at all, but merely a matter of common observation, viz., the extreme difficulty of getting a gas to have anything to do with electricity so long as the gas was in its ordinary condition. To this end he would use the electroscope represented in Fig. 1. The essential parts were the plate H and the gold leaf G set edgewise to it and connected to the top plate D. If a charge was given to H the gold leaf was attracted and touched H, and then was immediately repelled. So long as it held the charge acquired at the contact it stayed repelled, but if there was leakage from the top plate D it would on losing its charge be attracted again up to H and acquire a fresh charge. Hence with a steady leak the gold leaf would be set into a state of oscillation, alternately being attracted up to H and then repelled. The rate of oscillation was a measure of the rate of leakage.

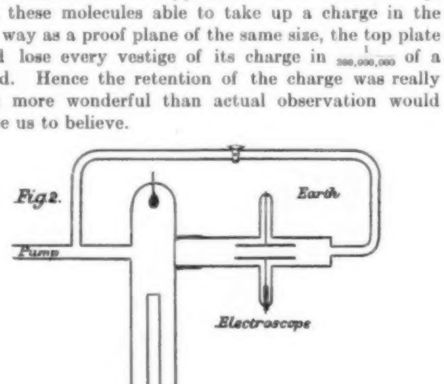
So long as the top plate was surrounded by ordinary air there was, the lecturer proceeded, no appreciable loss of charge, and the gold leaf remained away from the plate. Many, Sir Joseph proceeded, might ask why should any leakage be expected in such conditions. From the point of view of the nature of a gas its absence was, however, very remarkable. A gas consisted of a number of small particles, which were

Fig. 1.




continually hitting the charged surface of the plate D and going off again. If they carried electricity with them they would act as so many little proof planes, yet in spite of the fact that the plate was struck by the molecules of the air millions and millions of times per second there was no appreciable loss of electricity. Were these molecules able to take up a charge in the same way as a proof plane of the same size, the top plate would lose every vestige of its charge in $\frac{1}{300,000,000}$ of a second. Hence the retention of the charge was really much more wonderful than actual observation would induce us to believe.

Fig. 2.




The lecturer next showed that there was still no loss of charge when the plate was heated and ether poured over it. The ether evaporated off but left the charge behind it. The vapor, in fact, seemed, he said, incapable of receiving a charge, or at any rate resolutely refused to do so in the conditions of the experiment. This experiment had, Sir Joseph continued, been carried to a much greater pitch of accuracy. In some experiments the ether had been replaced by mercury, and the mercury evaporated off. The vapor still remained uncharged, although it was the vapor of a metal and came from a charged metallic surface.

This experiment showed one aspect of the behavior of gases to electricity. If, however, a gas were subjected to suitable treatment, then it was quite ready to take up a charge and to conduct electricity. There were various ways of achieving this end. It was, for example, sufficient to expose the gas to the radiation from a radioactive body. The lecturer showed this by directing on to the plate D of the electroscope a blast from a metal pipe at the entrance to which a little radium had been placed. A rapid leakage of electricity was thereby established, as shown by the vibrations of the gold leaf. This proved, he said, that not only was it possible by proper treatment to put a gas into a condition in which it conducted electricity, but that it retained this condition for at least the time taken for it to pass down the tube. He next varied the experiment by connecting the outer wall of the tube to one pole of a battery, and a wire strung along the axis of the tube to the other pole. In this case he showed that the conducting power conferred by the action of the radium had been almost entirely lost before the blast reached the discharge end of the tube.

From this experiment it followed, he said, that the conductivity of the gas was due to something mixed with it which was charged with electricity, as only charged bodies would be moved by the electric force between the central wire and the wall of the tube. In fact the process of making a gas into a conductor consisted in ejecting negative particles from its molecules. This could be done, as shown, by exposing the gas to the action of radioactive bodies. The Rontgen rays were also effective, as was also exposure to certain kinds of light. The peculiarity of the light effect lay in the fact that for success the wave-length must be less than a certain definite value which depended on the nature of the gas experimented with. Only light belonging to the extreme ultra-violet section of the spectrum was effective, and there was a sharp line of demarcation between the effective and ineffective portions of the spectrum. Red light, even if concentrated by lenses till it was able to set things on fire, had no effect, whilst success was easily attained with ultra-violet light of quite feeble intensity.

Radiation of still smaller wave-length was, the lecturer said, also effective. This was shown by the apparatus represented in Fig. 2. On the right of this is shown a horizontal tube containing one plate connected to earth and an opposing plate coupled up to a charged electroscope. Any current between these plates will cause the gold leaf of the electroscope to oscillate. The end of this horizontal tube where it enters the vertical tube is covered gastight by a film of celluloid, so thin that it shows the colors of the soap bubble. The vertical tube is a special form of cathode ray tube, and on establishing a discharge between the upper and lower electrodes the lecturer showed that there was a current between the two plates in the right-hand horizontal tube, as was indicated by the motion of the gold leaf of the electroscope. The cathode discharge, he said, gave rise to radiations which passed through the celluloid window and rendered conductive the gas beyond it.

He had already, Sir Joseph continued, shown that ordinary air was an extremely good insulator. When, however, the test was made with the greatest delicacy and care, it was found that air did not definitely refuse to conduct, but would convey a little electricity. This remnant of conductivity was far too small to be shown in a lecture experiment, but had nevertheless given rise to an immense amount of work in every country and under every conceivable condition. The problem was to find what this residual conductivity was due to. The most natural view was to attribute it to the radium in the earth scattered through the rocks and soils.

The conductivity of a gas, he went on, arose from the ejection of negative particles from the molecules. This residual conductivity of ordinary air showed that about eight molecules were thus affected per cubic centimeter per second. Since one cubic centimeter contained $2.75 \times 10^{19}$ molecules, and only eight became conductors per second, it followed that if any particular molecule "wanted" to be split up, it might have to wait ten-million-million years before its time came. It was this extremely small effect which had given so much trouble, and occasioned such heart-burnings and discussions in scientific societies throughout the world. As stated, it might be due to the radium in the soil, and accordingly tests had been made with vessels in ordinary rooms, or sunk ten to twelve feet below the surface of a pond; in the middle of the Atlantic, and over the ice covering frozen lakes. In all cases this residual conductivity remained. The idea arose that it might be intrinsic to the air itself—that some of the molecules split up spontaneously like those of radio-active bodies. Just before the war, however, McLellan, of Toronto, taking advantage of the climatic conditions, replaced the zinc vessel commonly used in the experiments with one constructed of ice, and found that the value of the conductivity was reduced to one-quarter of what it was when zinc vessels were used. It was now thought, therefore, that the effect was due to some trace of radio-activity in the zinc, either on the part of the metal itself, or of some impurity in it. The question had, the lecturer said, given more trouble

than some of the most celebrated problems in the history of physics.

The nature of the conductivity of gases was at one time much misunderstood. With any ordinary conductor, if the length were increased the resultant current was enfeebled. This result was so familiar as to seem a truism. With gases, however, just the opposite happened. The thinner the layer of gas across which conduction occurred the less the current, and in fact the conductivity was only appreciable when the thickness of the layer was substantial. This peculiarity was at the outset misunderstood. It arose from the fact that when a gas was rendered conductive by, say radium, every ion generated was made use of. By doubling the thickness twice as many were produced, and the greater the number of these particles the greater the rate of leakage, provided always that the force between the plates was sufficient to make all come up to the plates in the time available.

II

In the opening remarks at his second lecture, Sir Joseph Thomson observed that in his last lecture he had given reasons for concluding that when a gas conducted electricity, this electricity was carried by charged particles. In this respect the phenomenon resembled that of electrolysis, as to which the ordinary view was the current was conveyed by positively charged particles, such as hydrogen atoms, moving in one direction through the liquid, and by negatively charged particles going the opposite way; the mechanism at work, therefore, was very analogous to that which, we were led to believe, was responsible for the passage of a current through a gas. The phenomena in the latter case was, however, characterized by some strange features not normally exhibited in electrolysis. In the first place, an increase in the thickness of the slab of gas through which the current passed gave an increase of current, whilst with electrolytes such an increase of thickness enfeebled the current, and in this respect the behavior of a gas was at variance with the known behavior of electrolytes. Moreover, with the latter the effect of doubling the potential difference responsible for the flow was to double the current. With a gas, on the other hand, up to a certain stage there might be very great differences in the voltage drop without materially affecting the strength of the current, which, after a certain potential difference was reached, became practically constant. The reason for this peculiarity of gases lay in the fact that the number of carriers available for conveying the electricity from one electrode to the other was small, whilst in a liquid electrolyte the number was practically unlimited. In the gas not more than one molecule in a million-millions was ionized, whilst in the case of a liquid electrolyte the number of ions was an appreciable fraction of the whole number of molecules present.

As an analogy he might observe that in the transport of troops it was useless marching up men to a railway station in greater numbers than the trains available for taking them away could carry. The rate of transport to the other end would be limited by the train service available, and until this limit was reached the number carried over the rails would be governed by the rate at which the troops reached the station. When this rate equalled that for which carriage could be provided, no further crowding up the station would increase the number transmitted to the farther end of the line. In the case of a gas conducting electricity a point was soon reached at which the whole of the carriers available were used up, thus fixing a limit to the strength of the current, while in normal electrolysis there was practically an unlimited supply of carriers, and the current accordingly increased proportionately to the potential difference. Some liquids were, however, very bad conductors, and with these a stage was reached, just as with gases, in which an alteration in the potential difference had no effect on the current, so few carriers being available that a comparatively small current used them all up.

He had dwelt on this point, Sir Joseph continued, because this difference in the behavior of a conducting gas and a normal electrolyte had long been urged as a difficulty in accepting the idea that the current was carried through a gas by means of charged particles. It would be seen, however, that the explanation was perfectly simple, the special features of the flow being a mere matter of the number of carriers available.

In general, whether a gas were rendered conductive by the action of radium, by Rontgen rays, or other agents, the conductivity was very small. By applying to such a gas a suitable electric field it was, however, possible to make each charged particle "breed"—becoming thus the ancestor of a very numerous family. Under such conditions we might, in fact, get from the original particle a million of descendants. Suppose, for example, that we had two parallel plates, the one charged positively and the other negatively, with a conducting gas between. Each negative particle in the 'tween space would be pushed along from the negative plate towards the positive one, and its speed would depend on the force applied. So long as it moved slowly it passed through the gas without splitting up the molecules encountered. If, however, it moved above a certain pace, or rather, with more than a certain amount of energy, it would, on encountering a molecule, split it up into a negative particle and a positive one. The negative particle thus freed would also be pushed along like its progenitor, and when, under the action of the field, it acquired a sufficient speed, it would in its turn ionize another molecule. Each negative particle thus set free became accordingly the parent of two charged particles, and hence, before the original particle had moved very far, the total number of charged particles present would be increased to a very large extent.

Hence, when the potential between the two parallel plates was steadily increased, starting from a low value, a stage was at length reached at which the current increased with very great rapidity. The change came in quite sharply, and the gas suddenly became quite a good conductor, comparable with the best solution of sulphuric acid in water. This the lecturer demonstrated by showing that the energy absorbed by an exhausted bulb (containing a little residual gas) placed within a coil which was traversed by a very rapidly alternating current was as great as if the bulb had contained a mixture of sulphuric acid and water.

In experiments of this kind, the lecturer proceeded, although the gas showed very considerable conductivity, there was no indication of any approach to an unstable state. Nothing, in fact, comparable to what happened on the discharge of a Leyden jar. The discharge through the gas was quite orderly, and not comparable in intensity with the discharge of a jar, or of a lightning flash. The difference was due to the fact that in the orderly discharge in the bulb the negative particles alone acquired sufficient energy to ionize the molecules of the gas passed through. The current, it was true, increased rapidly, but this increase was finite, depending on the distance between the plates and the number of negative particles produced by the original ionizing agent. Matters became different if, in addition to the negative particles producing fresh ions, the positive particles also began to ionize the gas.

So long as the negative particles were alone able to split up molecules, the whole of the negative particles, parent and progeny, were chased along to the positive plate, where the whole were finally got rid of. If, however, the positive particles also began to ionize the gas, these, as they moved towards the negative plate, liberated fresh negative particles behind the original ones, and everything began over again, with the difference that the supply of negative particles available for ionization was greater than that at the start, and would continue to increase indefinitely. An enormous current could thus be built up, starting at the outset with but one or two charged particles. Two stages could, then, be recognized—one in which the negative particles alone acted as ionizers, and a second stage in which the positive particles also acquired sufficient energy to act.

A similar condition might also, the lecturer said, be produced in other ways. What was necessary was that fresh negative ions should be liberated near the negative plate. The Rontgen rays produced by the striking of the negative particles against the anti-cathode could therefore serve, generating fresh ions near the negative plate and producing an instability in which the current mounted up to an enormous value.

The most conspicuous example, and the most important, of this kind of discharge was afforded by the lightning flash. Although lightning was the oldest electrical phenomenon known, there was, until very recently not much precise information about it. Indeed, it was only within the past four or five years that we had any reliable measure of the amount of electricity which passed in a flash or any reliable estimate of the length of the flash. Nothing was known, moreover, as to whether the discharge carried to the earth a positive or a negative charge. There had, however, been a great number of general observations on lightning and its associated phenomena. A great number of these reports were difficult to believe, but amongst these the lecturer did not, he said, include statements as to balls of fire running about the ground and finally exploding with a sulfurous smell.

The researches of Mr. C. E. T. Wilson at Cambridge had, he proceeded, given us some definite measurements as to the order of the quantities with which we had to do in a lightning discharge. Fortunately, or unfortunately, England was not a very good place for the study of lightning. Mexico, where thunderstorms occurred daily, would be better. In England they were sporadic, and it commonly happened that when the storm occurred the would-be observer had not got his instruments ready. Mr. Wilson had, however, made a systematic study of the matter. His plan of procedure consisted in installing recording instruments at two stations some considerable distance apart. The charged thunder-cloud produced at places in its neighborhood an electric force, the intensity of which was recorded by the instruments at the two stations. If the cloud discharged, the part of the force due to this loss of electricity disappeared and the instruments recorded a kink, the magnitude of which differed at the two stations. Its size depended upon only two variables, viz., the quantity of electricity discharged and the distance of the cloud from the station. Hence the two simultaneous observations served to determine both the quantity of electricity passed and the height of the cloud, that was to say, the length of the flash. In this way Wilson found that the length of an ordinary flash was 10 km., or about six miles, whilst the quantity of electricity passed was about 30 coulombs. He further found that even at his stations, which were not immediately under the flash, the increase of potential was at the rate of 2,000 volts per meter of vertical height, and it was no doubt much greater immediately in the line of the discharge. Taking this value as a minimum, the actual value of the potential difference between the cloud and the earth at the moment the spark passed was therefore 20,000,000 volts. Hence, as the electricity passed was 30 coulombs, the energy expended was 6 x $10^{16}$ ergs, or about 600,000 ton-meters. It was not surprising, therefore, that lightning flashes were so destructive; it was, in fact, rather remarkable that they did so little damage. Fortunately the greater part of their energy was not spent in destructive purposes.

Thunder was due to an impulsive wave produced all along the track of a flash. This was apparent with even a comparatively short spark, as he demonstrated with an apparatus consisting of a bulb containing air and provided with a water-gage of fine bore. On discharging a spark through the bulb a wave of high pressure was produced, which was indicated by the motion of the water in the gage. Lightning, he stated, produced the same effect, but on an infinitely greater scale.

[TO BE CONTINUED]

## Physico-chemical Considerations on Benzol Recovery from Coal-Gas

The author deals with the effect of viscosity, temperature, and composition on the efficiency of creosote as a washing medium for extracting benzol from coal gas. In the case of washable products of coal gas dissolved in creosote, each dissolved body exerts a fraction of its own maximum vapor pressure equivalent to the percentage in which it occurs in the creosote. From a series of vapor pressure curves given, the percentage of these constituents which the gas could carry if saturated may be ascertained. From further data the author deduces the fact that creosote can remove the toluene from 3.55 times the quantity of gas which saturates it with respect to benzene, and solvent naphtha from 10.7 times the same amount. The effect of temperature on the rate of solution, using 100 and 50 gallons of creosote per ton of coal respectively, is shown in a series of curves. A suitable wash oil for benzol extraction should not give off any large proportion of light oils when steam distilled, must take up heat quickly and cool quickly, must flow or spray readily at the washing temperature, must not emulsify with water, and must not give up naphthalene to the gas. The influence on viscosity of various factors, is indicated by curves, showing effect of temperature naphthalene content, distillation tests, etc., and the author sums up his observations in the following conclusions: (1) Efficiency of washing is improved by using a cold oil. (2) The lighter oils in creosote help the washing process by lessening the viscosity, but are readily distilled out by steam and contaminate the benzol. (3) Naphthalene tends to lower the viscosity but under certain conditions may pass into the gas. (4) Creosote fractions boiling above 300° C. greatly increase the viscosity. (5) A good creosote should be as fluid as possible at 10° to 15° C., give little oil distillate when steam distilled, and contain a minimum amount of naphthalene. (6) Much improved cooling is obtained by using a creosote of which the viscosity rises very little when cooled to 10° to 15° C., and the benzolized oil is more readily heated. (7) Efficiency of washing is improved by increasing the intimacy of contact between oil and gas. Washers on the spraying or atomizing principle appear to offer the best field for development in this direction. (8) Specific gravity is no criterion as to whether a mixture of blast-furnace and coal-tar creosote is "spent" or not, viscosity being the best test. (9) Sufficient creosote should be in circulation to prevent the removal of light oils leaving a creosote of high viscosity. —*Note from the Jour. Soc. Chem. Ind. in a paper by. T. F. E. Rhead in Gas. J.*

# Automatic Pistols*

## Mechanism of a Recently Adopted Type of Military Arms

By H. Volta

Automatic pistols, which until recently have been arms reserved for civil life, have been adopted in the army since the war of the trenches rendered hand-to-hand fighting inevitable. Hence they deserve to be described in some detail, particularly since the problems they often meet are solved in a different manner from the way in which the same problems are met in machine guns.

While Sir Henry Bessemer took out the first patent for an automatic gun as early as 1854, it is not until

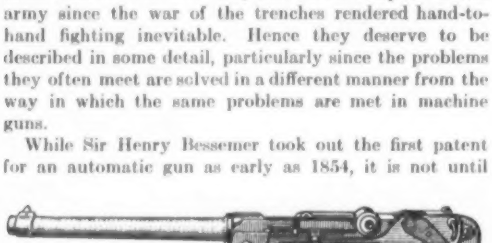


**Fig. 1. The Borchardt**

1893 that we find, in the Borchardt pistol, the principal qualities of our automatic pistols of today.

The exterior forms depend not only upon the mechanism, but also upon the placing of the magazine, which may be constituted by the butt of the arm itself (Luger) called also the Parabellum, Borchardt, Browning, or by a special part of the arm (Mauser, Bergmann). All other models may be associated with one of these types, those of the Browning type being the best known.

We have seen in descriptions of machine guns that the motor force necessary to execute the operations of extracting the fired cartridge, introducing the new cartridge, closing the breech, can be effected either by borrowing a portion of the gases from the powder (Colt, Hotchkiss,

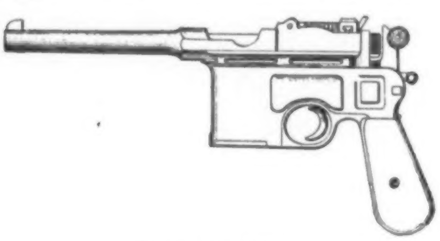


**Fig. 3. The Mauser**

French machine guns), or by utilizing the force of the recoil of the arm (Maxim, Bergmann, Nordenfeldt, Schwartzlose etc., machine guns). While the first system has been applied but little to automatic pistols (Clair pistol), the recoil, on the other hand, is utilized in all the types which have had a commercial success.

We can divide them into two classes: pistols with and without bolts, a distinction which requires some explanation.

After firing the shot, so long as the ball is still in the gun, it is subject to the propulsive action of the gases; hence for a long time it was thought indispensable, in order to obtain sufficiently effective penetration of the ball, to fasten, or as it is termed, to bolt the breech to the gun, until the moment when the ball left the gun, so as not to reduce the action of the gases.

Therefore the mechanical problem to be solved was as follows: to fasten the breech to the barrel in such manner that these two parts will recoil together while the ball is in the barrel, then stop the barrel while allowing the breech to continue its recoil motion and thereby accomplishing the various operations of recharging the arm. Let us here describe the Mannlicher pistol, which operates upon this principle.

At the moment of firing, the firing-pin P under the action of the hammer c strikes the cartridge (Fig. 6). The shot leaves. The recoil produced at this instant projects the bolt V towards the rear, but this piece united to the case of the breech block B by a lever L pivoted upon the latter, causes its displacement towards the rear, and consequently also that of the barrel C'. The spring R is then compressed until the moment when a projection S of the case B strikes against the frame, thus limiting the recoil. During this time the hammer, which passes across the lever L, has received an impulse sufficient to bring it back to the firing position.

At this moment the lever L escapes from the little abutment on the rear end of the bolt upon which it rested, and is lowered by the action of the bolt which can thus continue its path towards the rear. The barrel is immobilized and cannot return forward in spite of the action of the spring R', any more than can the breech-box B, for the lever L is caught on the lower notch of the abutment b.

The ejection of the empty shell is then produced by the extracter E, while a new cartridge is introduced in its place by means of the thrust of the spring of the magazine. It is pushed into the chamber by the spring R which brings back the bolt V into position. The latter, at a certain point in its path, lifts the lever L, which rises under the action of the spring R', permitting the breech-box B to resume its first position. The arm is now again ready to fire.

The typical operations which we have just described are reproduced in all automatic pistols, the only difference being in the method of bolting adopted, which can be obtained either by a movable piece (Mannlicher, Mauser, Charola Anita, etc.), by a crank (Borchardt, Luger-Parabellum), or by lateral displacement (Colt,

**Fig. 5. The Browning**

Knoble), or finally by the rotation of the bolt (Schwartzlose, Hellfritzsch).

We will pass them rapidly in review. In the Borchardt and Parabellum pistols the bolt is united with the breech-box (bôite de culasse) by two cranks jointed together by a hinge so arranged that in the position of the bolting this hinge and the pivots of the cranks upon the breech-box and upon the bolt are in a straight line. Whatever be the effort exerted, following this direction the articulation will act as a solid whole. If, on the contrary, the hinge is not on the line of the two pivots, the same effort will increase the displacement, thus

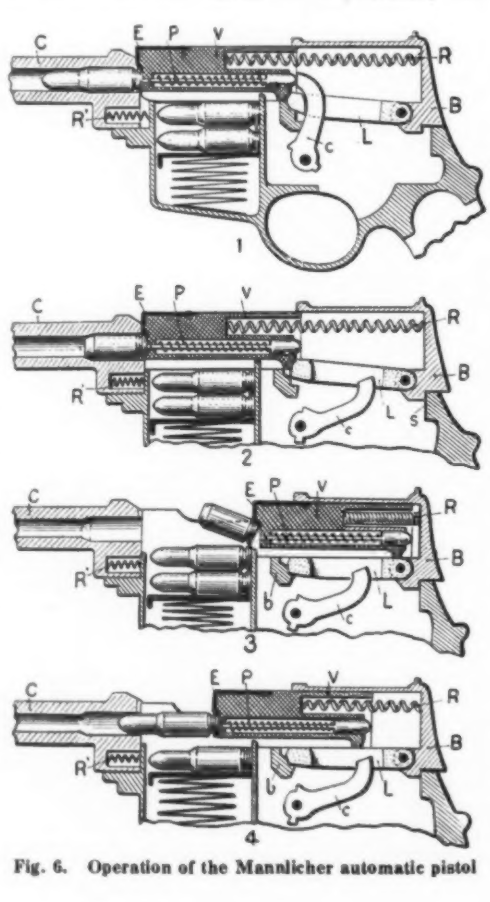



**Fig. 6. Operation of the Mannlicher automatic pistol**

accomplishing the opening of the breech: Take for example the Borchardt pistol (Fig. 7).

When the shot is fired the barrel C and the breech-box B, as well as the bolt V, are projected to the rear, the force of recoil being exerted along the line $v \times b$, $v$ and $b$ being the two pivots of the two cranks jointed at X. The whole passes from the position 1 to the posi-

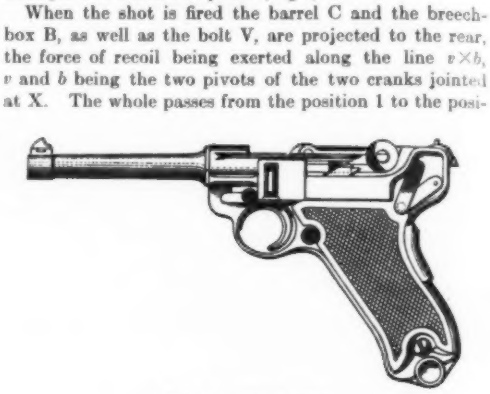


**Fig. 2. The Luger**

tion 2. At this moment the barrel strikes against the frame B' of the pistol, and the little roller, g, carried by the prolongation of the rear crank is swerved downward. The joint X rises, the two cranks revolving around the points of articulation $v$ and $b$, and the bolt is displaced thereby compressing the recoil spring R. When it reaches the bottom of its path, the extraction is made, a new cartridge has been introduced, as in the Mannlicher pistol, and spring R again closes the arm.

Among the bolt-pistols which act by lateral displacement, Bergmann's may be mentioned, in which it is the bolt which is displaced, and Colt's, in which the barrel is movable. In this the movement is obtained

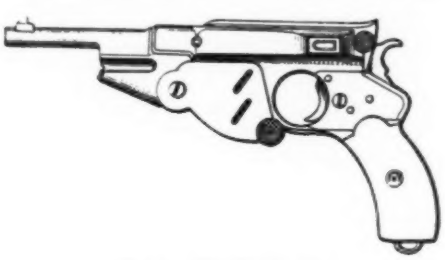


**Fig. 4. The Bergmann**

by two cranks $b$ $b$ (Fig. 8), which unite the barrel to the frame.

The barrel B has teeth D on its top side, which engage with the notches E of the bolt. When the latter flies back, carrying with it the barrel, the latter is lowered by the play of the small cranks until the teeth D escape from the notches so as to free the bolt, which continues its path to the rear by itself, as indicated in the figure. In pistols acting by rotation (Schwartzlose, Hellfritzsch, Roth, Sauer, 1897 Browning model, etc.), the barrel and the bolt are drawn by each other by reason of the solid tenons of one which engage the notches upon the other, and from which they are disengaged by rotation.

Fig. 9 shows the section of a Hellfritzsch in which it is the bolt V that bears the tenons $t$, which are able to pass across the grooves carried by the barrel. When the bolt is revolved its tenons engage with those which the barrel bears and the two parts form a rigid whole. On account of the form of the grooves, separation occurs at the proper moment. The recoil spring, not shown, is lodged in the bolt, and the barrel is surrounded by a spring R drawing it towards the rear.

It is evident from the preceding brief exposition that all these arms involve a complex mechanism in spite of the ingenuity displayed. Hence non-bolted pistols, simpler and cheaper, have had much success.

Since in these we cease to have the barrel and the breech connected at the moment of firing, it is necessary to use other means to prevent the immediate opening of the barrel towards the rear, whose effect would be to allow the largest part of the gases to escape, thus lessening the force of the shot. The methods used are the recoil spring, the mass of the bolt, and supplementary friction.

Browning had the idea of giving the bolt a mass as large as the dimensions of the gun permit, in order to suppress or reduce to the minimum the chief defect of the recoil spring. The spring is, in fact, less resistant at

*From *La Nature*.

the beginning of the compression than later on. In the case before us it is at the moment when the pressure of gases is strongest, when the shot is fired, that the non-

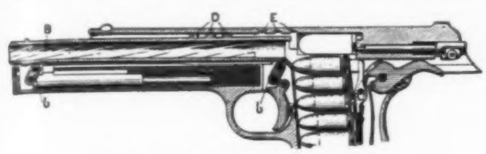


Fig. 8. Mechanism of the Colt

compressed spring is least resistant. Browning achieves the maximum mass by prolonging the bolt below the barrel. It is particularly easy to dismount. For this purpose it suffices, after having drawn the bolt to the rear in the position represented, to revolve the barrel by hand so as to disengage the spurs B from corresponding ribs A of the frame.

Fig. 10 shows the 9 mm. Browning of the Belgian army, and Fig. 11 the 6 mm. or 1900 Browning model in which the rod Y of the recoil spring, in place of being fastened directly to the bolt is fastened to a lever K, pivoted upon the bolt at *i* and whose lower end acts on the firing-pin. When the bolt is driven forward by the recoil spring the firing-pin is held at the rear by the mechanism of the lock; but, in place of being driven towards the bolt by a special spring, has this done by the recoil spring by means of the lever K. The study of the ingenious mechanism of the hammer, which is hidden in the butt of the arm itself, would carry us too far, as would also that of the more or less successful systems of Bergmann, White, Francken, Mannlicher, etc.

Fig. 10. Belgian Army Browning

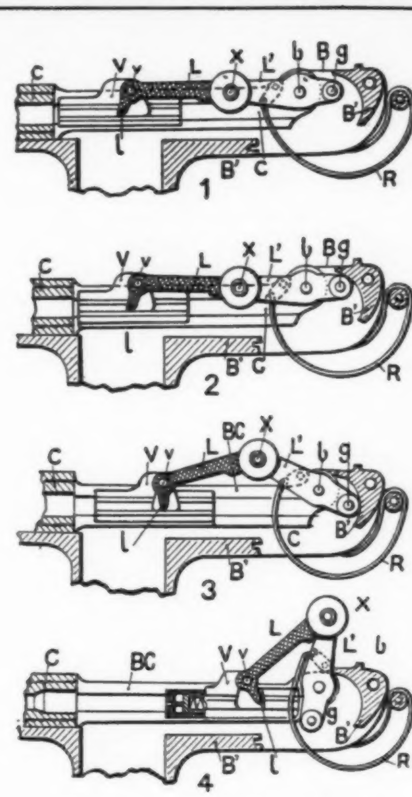


Fig. 7. Operation of the Borchardt

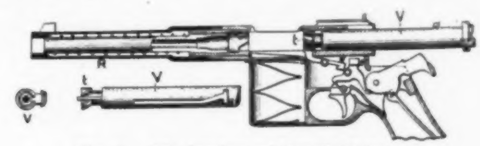


Fig. 9. Mechanism of the Hellfritzsch

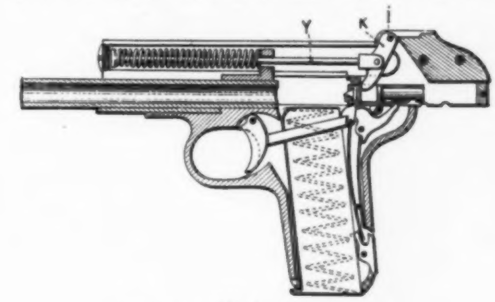


Fig. 11. 1900 Model Browning

## Osmotic Pressure

The theory that osmotic pressure is due to bombardment of the walls of the containing vessel by the particles of solute has met with considerable criticism, both from the chemical and physical sides (compare, *e. g.*, van Laar, Proc. Amsterdam Academy, Vol. xvii, p. 1241; Vol. xviii, p. 184; abstracted in *Nature*, March 16th, 1916). However, at the discussion on osmotic pressure before the Faraday Society on May 1st, with Sir Oliver Lodge in the chair, the kinetic theory more than held its own. It was claimed by Prof. A. W. Porter that this theory is the only one which gives directly the experimentally obtained values for dilute solutions; that it has now been placed on a sound experimental basis as a result of Perrin's investigations, which show that particles suspended in a liquid, and therefore also the molecules of the solute, are in rapid motion to the precise amount required by the theory; and that any other theory of osmotic pressure must not only be competent to account for the observed facts, but must explain the absence of the effects that we have a right to expect from the molecular agitation of the solute. These claims were not seriously shaken by the criticisms of subsequent speakers, and towards the close of the meeting the chairman expressed his general agreement with the arguments put forward in favor of the kinetic theory.

Mr. W. R. Bousfield's contention that it is the solvent and not the solute which is active in osmotic pressure may be met, as Sir Oliver Lodge pointed out, in a simple and therefore necessarily incomplete way as follows. Imagine a closed vessel full (or practically full) of water, and divided into two compartments by a semipermeable membrane. The pressures on the two sides of the membrane compensate each other, but if a little sugar is dissolved in one compartment an *additional* pressure, due to the presence of the solute, is set up on that side. The contention that it is necessary to look to the solvent, and the solvent only, as the source of the pressure is therefore not established, but Bousfield's view that osmotic pressure is connected with the presence of solvent vapor (approximately obeying the gas laws) in the molecular interspaces, deserves consideration on its merits.

It will not be denied that there are difficulties in applying the kinetic theory to relatively concentrated solutions (more particularly as regards the correction for the volume of the solute), just as there are difficulties in the application of the kinetic theory to compressed gases. It is remarkable that the deviations from the simple gas laws are smaller for solutions than for gases, and in one case at least (compare Sackur and Stern, *Zeitsch. physikal. Chem.*, 1912, Vol. lxxxi, p. 441) this has been shown to be in accordance with the kinetic theory of osmotic pressure.

Both Prof. Porter and Mr. Bousfield ascribe the deviation of osmotic pressure from simple laws solely to hydration of the solute, and proceed to calculate the degree of hydration of the solute particles on this assumption. As, however, such simple laws do not hold for the gaseous state, in which hydration is necessarily absent, these "hydration numbers" do not inspire much confidence, more particularly as the variation of some of them with concentration in relatively dilute solution appears difficult to reconcile with the law of mass action. Unfortunately they cannot be independently tested, as no satisfactory method of measuring hydration in solution has yet been discovered.

Although the magnitude of the osmotic pressure, as equilibrium pressure, is independent of the nature of the membrane provided the latter is truly semipermeable, the mechanism of osmosis, including the part played by the membrane, is of great interest and importance. The very suggestive investigations of Adrian Brown and Tinker on the permeability and other properties of membranes have already added substantially to our knowledge of these questions. As regards the bearing of theories of osmotic pressure on osmosis, the suggestion of van Laar that the pressure of the sugar molecules as postulated by the kinetic theory would prevent water flowing inwards does not appear well founded. The most satisfactory picture of the process is probably obtained by analogy with Ramsay's well-known experiment with a cell provided with a palladium membrane permeable for hydrogen, but not for nitrogen. Although the cell contained nitrogen at half an atmosphere pressure, when it was surrounded by hydrogen the latter entered until its partial pressure inside was practically equal to its pressure outside.—From *Nature* (London).

## Melting Zirconia and Production of Ware Therefrom

Raw zirconia is an unsatisfactory material for the production of refractory articles as they crack readily and soon fall to pieces. If a bond is used to prevent this, the refractoriness of the articles is seriously impaired. The author has found that zirconia which has been heated to above 2,000° C., and especially fused zirconia, is free from this objection and is excellent for the manufacture of refractory ware. The use of a carbon resistance furnace or of an ordinary electric arc for fusing the zirconia is unsatisfactory on account of the formation of carbide. The best results are obtained by embedding a carbon electrode in coarsely ground calcined zirconia, heating the latter with the arc formed from a second carbon electrode and thus partially melting the zirconia with formation of some carbide. The latter then acts as an electrode and the zirconia fuses and continues to do so when the upper carbon electrode is slowly withdrawn. After a time, the arc becomes quiet and the fusion proceeds rapidly. Arcs 30 cm. long, accompanied by a molten mass of zirconia 15 cm. in diameter, have repeatedly been obtained in half an hour with a current of 50 amps. at 220 volts, the resulting blocks of zirconia being pure, and white, with a yellowish sheen in parts, due to traces of iron. The fused zirconia is ground for 100 hours or more in a steel ball mill and any iron taken up from the latter is removed by treating the powder with acid. The zirconia is moulded or pressed into articles, with or without the addition of an organic bond. By reducing a part of the zirconia to the colloidal form it is possible to render the whole material plastic and to manufacture articles from it by "slip-casting" in plaster moulds in the same manner as porcelain. Crucibles made by this process are as fine as those made of porcelain. Attempts to cast articles from molten zirconia have, hitherto, been unsuccessful. The articles are burned at 2,300°—2,400° C. until they cease to contract; if properly burned they should "ring" clearly when struck. The burning temperature may be reduced to 2,100° C. by adding a little boric or phosphoric acid to the zirconia before making it into articles, but this is not recommended. The oven used is constructed chiefly of fused zirconia; it is cylindrical in shape, with internal dimensions of 20 cm. by 30 cm., and is of the injector type. The fuel is either town's gas, petroleum, or acetylene supplied with a blast of air and, later, with oxygen. The author's furnace has been in use for 200 hours without requiring any repairs. A uniform yet very high temperature and an oxidizing atmosphere can be obtained without difficulty, so that ovens of this type may be useful for testing the fusibility of refractory materials up to 3,000° C. The shrinkage of the articles during drying and burning varies with the size of the particles and zirconia. If a finely ground material is used, the total shrinkage is about 20 per cent. Fused zirconia resembles fused quartz in some respects, but when cooled rapidly it forms an opaque mass of minute crystals and not a clear glass. The crushing strength of cold fused zirconia is many times that of cold quartz, so that it is exceedingly difficult to grind. Such zirconia has a high thermal endurance and is not affected when heated to redness and then plunged into cold water. A large block may be heated irregularly by an oxyhydrogen blowpipe without showing any signs of spalling. A block of fused zirconia maintained at 2,200° C. for thirty hours showed no signs of disintegration when cold. Hence, fused zirconia appears to be a refractory, material of extraordinary value. It has a hardness between quartz and corundum, a specific gravity of 5.89, a porosity below 1 per cent, and a melting point—determined with a Lummer-Kurlbaum pyrometer—between 2,950° and 3,000° C., but 0.5 per cent of impurity reduces this by 100°.—Note in *Jour. Soc. Chem. Ind.*, on an article by E. Podszus, in *Z. Angew, Chem.*

# The Conservation of Garments in Laundering*

## The Responsibilities of the Manufacturer, the User and the Launderer

By H. G. Elledge, Industrial Fellow of the Mellon Institute of the University of Pittsburgh

DEFINITE information regarding the length of time a textile in use should last is entirely lacking. One hotel which has been under the writer's observation for nearly two years, has been in operation for two and one-half years. When this hotel opened it was sufficiently stocked with table linen, so that when doing capacity business one-third of the entire stock would require laundering every day. There is, of course, no absolute record of the number of times each article of this lot of linen has been used and laundered, but it is a conservative estimate that each piece of table linen in the hotel has been subjected to laundering 228 times, assuming that for one-half of the time the hotel enjoyed capacity business and for the other one-half of that business. Some of the napkins are beginning to show thin spots, but there are no holes or ragged edges. As a consequence, the manager is entirely satisfied with his purchase of linen as well as his launderer. The appearance of this linen is such as to please the most fastidious.

This stock of linen was of good quality when received from the manufacturer, but contributing quite as much toward the good showing has been the care in using and laundering. It has not been the practise of the hotel help to use the slightly soiled napkins as kitchen towels or dust cloths, as is actually the case in so many hotels and restaurants. The laundry gave this linen just the treatment necessary for keeping it snowy white, and no more.

In the above narrative, the writer has indicated the three agents of responsibility that must function together if the useful life of any fabric is to be conserved. The cloth must be of honest quality. The cloth must be properly cared for—not soiled beyond the extent due to the ordinary conditions of usage. Towels to be kept white and of attractive appearance, and yet have a proper life, should not be used for shoe shining, etc. In this lies the responsibility of the user. The laundryman must judge, or have an organized group of workers to determine the nature and extent of the treatment necessary to keep the fabric of attractive appearance and yield the longest life in service. This is the responsibility of the launderer.

### THE LAUNDRY OWNERS' NATIONAL ASSOCIATION'S BUREAU OF TEXTILES

The Association which maintains the researches on the problems of laundry technology in the Mellon Institute of Industrial Research of the University of Pittsburgh, which have engaged the writer's entire attention for the past two years, also operates a Bureau of Textiles.[1]

To cite one of the illustrative instances of the Bureau's services, there was a table cloth laundered for the first time with a lot of sixty table cloths. This one cloth came from the ironer with one border shrunken. By common logic, the laundryman knew that it was through no fault of the laundering process; but without some specific knowledge of what might cause the shrinking or where the responsibility might rest, it was difficult for him to offer a satisfactory explanation to the irate owner of the table cloth.

It is realized that there are many grades of raw materials that must be utilized in the total output of our textile mills, that automatic machinery and human hands are not infallible, and that economic necessity demands that all products of the mills at all suitable to human needs must be, somehow, marketed. Yet, it is the feeling on the part of the laundryowners that the buyers, especially the housewives, should become more discriminating buyers. In order to assist to this end, some means should be devised to curtail deception in the selling of fabrics, whether this deception be perpetrated by the weaver or unscrupulous jobber into whose hands defective textiles might fall. In other words, goods classified as defective or seconds in the reputable mills should be so labeled or indelibly branded that they would less easily be passed as good cloth, should they find their way into the hands of the unscrupulous, and hence to the unwary consumer.

It is fully realized by the writer that the difficulties of the cotton manufacturer begin in the cotton fields and extend through every treatment the cotton fiber receives, to the finished cloth. The wonder is not at the fact that evidence of the "scratch-up" needle is often found by the launderer on first washing a piece of goods, but rather it is surprising that it is not more often discovered. These considerations may casually appear to be somewhat beyond the scope of the writer's work. They are, however, vitally important in their relation to the problems under investigation.

Other factors relating to the responsibility of the manufacturer, of more purely a chemical nature and which offer a field for research, are the bleaching of gray cloth and the allowable weighting of silk. Better standards of control in the bleaching process, it seems to the writer, might be desirable. It is insufficient to state that a certain treatment does or does not tender a piece of cloth. Qualitatively any treatment that is given any fabric during the process of bleaching or washing has some tendering effect, but we are concerned about quantitative results. How much, for example, does this or that process or a certain bleaching agent tender a piece of gray cloth of a certain weight and texture?

### RESPONSIBILITY OF THE USERS

The responsibility of the user in the life of a fabric seems so obvious that the writer felt inclined to refrain from discussing the factors thereof; it is, however, one of the most important considerations. A year or two ago any observing traveler might have frequently noted that the porter on a Pullman sleeper as a matter of practice dusted off the woodwork of the car with a pillow case, and that frequently a pillow case or face towel was employed by the porter to give the traveler's shoes the final touches. The Pullman Company owns its own linen, and, after this condition was explained by a progressive laundry owner, such unnecessary abuse of the linen supply has been prohibited.

Absurd styles and carelessness on the part of the user many times reduce the life of the textile article. For instance, a child's play garment should obviously be made of a weave that would endure more severe treatment than should be given to cotton underwear.

### THE LIFE OF A STARCHED COLLAR

Historically, the growth of the laundry industry is intimately related with that of the popularity of the detachable starched collar.

To illustrate how some laundry owners have established control indices on their washing process, affording thereby data on that amount of the depreciation of a garment that is chargeable to wear in use and to wear in laundrying, the following example is cited: It is the practice in many laundries to place a date numeral, sometimes in code, on every new collar that is marked in. Others place a mark on each collar in such a way that the number of trips a certain collar has made through the laundry can easily be read. In addition to this, in one laundry that has come under the writer's notice, a lot of new collars were marked and run through the usual process of laundering and finishing, *i. e.*, starching and ironing. Then they were, without being worn, repeatedly put through the process until the collar showed signs of failure by cracking at the folds. These collars showed a life of from thirty-five to forty trips through the laundry process, whereas a good showing for worn collars in the identical processes of washing is a life of about twenty trips through the laundry. This indicates that the actual wear in use is forty-three to fifty per cent of the life of a collar. Much of the most severe damage that is done to a starched collar, it may be remarked in passing, is attributable to improper manipulating in putting it on and taking it off.

### STANDARDS OF WORK DEMANDED BY PATRONS

The average laundry has very definite standards with which the work must comply. The appearance must be that demanded by the patron, or, in reality, that which the laundryman conceives to be required by the patron. The general experience of laundry owners in selling service seems to be that to the patron the appearance of the laundered work is held of more importance than any extra conservation of the life of the goods, the latter consideration constituting the point of secondary importance. With some, however, the order is reversed, so that neither factor can be lost sight of.

The restaurant owner who sends in severely soiled table linen usually wants his linen returned with the same snowy whiteness as is demanded by the manager of the first-class hotel mentioned in the introduction. Or, again, the housewife, who thinks that, because the power laundry does her work, the household linen just as well may be badly soiled, requires the same standard of appearance in the laundered linen as is exacted by the housewife who cares for her linen as though she or her washerwoman expected to do the laundering in her home. Another requirement is that the laundering process shall be no more severe than is required to maintain the proper standard of appearance. Still another objective to be attained is that the linen be returned to the patron in a sanitary condition. As will be pointed out later, the power laundry process automatically takes care of this feature.

### THE EFFECTIVENESS OF WASHING MATERIALS

In the investigation presented below, the mechanical equipment of laundries has been accepted as it exists in practice. While, as the investigation proceeded, the writer was observant for any possible improvement in washroom equipment, he early became impressed with the fact that a remarkable approach to perfection has been attained in mechanism, truly a monument to American ingenuity. The detergent reagents were, therefore, studied, bearing in mind the washroom equipment as it is.

It is obvious that a good supply of soft water is the most important of the washroom requirements. Where natural water of less than 8 grains of calcium carbonate, equivalent per U. S. gallon, is not to be had, the need of a water softening plant is indicated.

### DETERGENT VALUE OF SOAP

The reagent next in importance is soap, and accordingly a study of the more recent theories concerning the detergent action of soap solutions has been made, not so much with the object of advancing any theory or modification of an existing theory, but more with the idea of finding a basis for measuring the value of the alkaline salts used in washing fabrics. By somewhat extending the work of Hillyer,[2] we feel that we have found a means of determining the relative values of these salts. These findings have been discussed in an earlier paper.[3] As far as the evaluation of laundry soap is concerned, investigations to date indicate that the most satisfactory method is on the basis of the fatty acids, alkali as soap and alkali as filler determinations, taking into consideration objectionable impurities and the temperature at which a given concentration of the soap solution tends to jell, this being indicative of what the laundryman terms the rinsing properties. In connection with, and in addition to, the usual analysis,[4] the drop number or relative surface tension measurement, as described by Hillyer,[5] and more recently by Shorter,[6] has been found useful by the writer in comparing the detergent values of two or more soaps. The drop number method can not be used as an absolute index for an unanalyzed soap, because a smaller percentage of real soap plus a larger percentage of carbonate alkali might indicate a higher value than a pure soap. For the present it is necessary, and, indeed, desirable, to recognize a difference between the commercial values and the detergent values of soaps.

### BLEACHING

While bleaching and its attendant souring is likely to be the most harmful of the reactions employed, it is evident that to obtain the whiteness desired would be impossible in some cases without employing a bleaching bath. In many classes of white work, the bleaching is, however, omitted.

So far as our investigations have progressed, sodium hypochlorite, prepared either electrolytically, or from bleaching powder and soda, or from chlorine gas and caustic soda, seems to be the best of the available materials for effecting laundry bleaching. Proprietary bleaching materials, composed of soda ash and sodium perborate, or soda ash and sodium peroxide, have been offered to the laundry trade. An obvious objection to those containing sodium peroxide is the instability of that compound. Several samples claimed to be of such a nature have been found, upon examination, to contain no oxidizing power whatever.

### EMULSIFIED SOLVENTS

Many stains are encountered in laundering which do not readily yield to soap and alkali washing or to oxidizing bleaching. Kerosene or other solvents for greases

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[1] J. Clair Stone, of Minneapolis, Minn., is the active Director of this Bureau.

[2] *J. Am. Chem. Soc.*, 25 (1903), 511, 524 and 1256.

[3] Elledge and Isherwood, *J. Ind. Eng. Chem.*, 8 (1916), 793.

[4] See Circular of Bureau of Standards, No. 62.

[5] *Loc. cit*

[6] *J. Soc. Dyers and Colorists*, 32 (1916), 99–108

and waxes, emulsified in water solutions of soap and alkali, have been offered to meet the needs presented by these conditions. Some of these have been found to be very good examples of stable emulsions, but to possess a questionable value in washing clothes.

The writer can not quite agree with the conclusions of Pickering[7] that hydrocarbons are dissolved by soap solutions. The writer has found, however, that a hydrocarbon oil, such as kerosene, with about one per cent of oleic acid dissolved in it, is effective in removing oil and grease stains by the following procedure: Treat the dry soiled garment or cloth with the one per cent solution of oleic acid in kerosene, remove this solution as completely as possible by wringing (preferably in a centrifuge), then emulsify the residue by washing the garment or cloth in a warm, alkaline bath. The oils left in the cloth are more readily emulsified by reason of the fatty acid already diffused throughout the mass. A similar application of this principle has been made for removing paint stains, using the vehicle of the paint with one per cent of oleic acid dissolved in it as the solvent and then operating as outlined above.

Fabrics are often more severely treated to remove a stain than would be necessary if the laundryman were advised by the patron as to the nature of the stain. In such instances the patron could often contribute to the conservation of the fabric by giving the laundryman the history of the stain. The use of the proper reagent, such as potassium permanganate and oxalic acid in the case of iron stains, is the practical procedure to restore the fabric to its former condition with the least loss of tensile strength. Other stains, such as "wagon stains" (wet street dirt), treated immediately following the soiling are easily removed, but after being allowed to dry are very obstinate.

Instruction as to the proper use and care of fabrics, such as is being disseminated through domestic science schools and magazines, will contribute in a large measure to the conservation of fabrics by promoting the coöperative assistance of the patron to the laundry.

### EFFECT OF REAGENTS AND MECHANICAL TREATMENT

The effect of all the washing materials on the tensile strength of fabrics has been studied by Faragher.[8] His tests were of necessity of the accelerated order and were conducted in the laboratory. It seemed desirable, therefore, to extend his work by securing further data concerning the effect of these reagents under conditions of rinsing and mechanical influences obtaining in usual practice.

In order to accomplish this, the following experiments were carried out in the laboratory "machine," a model of the usual type employed in power laundries:

To determine the effect of mechanical action in the water of the machine on cotton and linens, 8 pounds of miscellaneous cotton garments were placed in the machine with 10 gallons of cold water (room temperature). This load of 3 pounds of goods per cubic foot of capacity was chosen to make the test comparable to what had been found to be the most efficient loading of the machines in actual practice. In this load was placed a handkerchief (of the quality usually retailed at 25 cents), the breaking strength of which had been determined at four places along the warp and four places along the filling. The machine was then started and run continuously for 25 hours. At the end of this time the handkerchief was removed, dried in the centrifuge, ironed and the breaking strength determined as before. The loss in strength was then calculated on the basis of the original strength. With cold water the loss amounted to 0.18 per cent per hour of treatment. The results of similarly conducted tests, but varying reagents, are as shown below:

| | |
|---|---|
| Hot water, 10 gal. | loss 0.2770% per hour of treatment. |
| Cold water, 10 gal., 041 oz. soda ash, representing a concentration 6 times as great as recommended in washroom formulas | loss same order as for cold water. |
| Hot water, 10 gal., 0.8 lb. soda ash | loss 0.'8% per hour of treatment. |
| Hot water, 10 gal., 6 oz. soap (Suds did not persist throughout). | loss 0.5% per hour of treatment. |
| Hot water, 10 gal., 6 oz. soap 0.8 lb. soda (Copious suds throughout). | loss 0.22% per hour of treatment. |

It will be seen from this statement that, as would be expected, hot water plus mechanical wear is greater than cold water plus mechanical wear; that, with cold water, sodium carbonate, in a concentration of three times the maximum concentration usually employed, had an effect entirely obscured by the mechanical effect; and that the combined effect of soap and soda in which a good suds persisted, even though the concentration of alkali was six times the maximum usually employed in the laundry, was less than that of a soap bath alone in which the suds did not persist, and even somewhat less than hot water alone.

These results are entirely in accord with those of Faragher, from which he concludes that soap and soda are the least harmful of all the washing reagents, and even go further in that they indicate that, under conditions of practice necessary to cleanse fabrics, soap and soda, in addition to their detergent properties, actually have a conservative function in the washing process.

Twelve handkerchiefs, similar to the ones used in the above tests, were tested for breaking strength, and soiled with a uniform dirt mixture made of 1½ grams of beef extract, 1 gram of dried egg albumen, and 2 grams of lampblack, all mixed into a good solution and suspension in 4 liters of water. Six of these handkerchiefs were sent to a power laundry and six were sent to a reliable washerwoman.

After each lot had been soiled and washed ten times, the breaking strength was again determined. The loss per trip to the laundry amounted to 2.6 per cent of the original strength, while the loss per trip to the washerwoman was 2.1 per cent of the original strength. The limit of error was estimated to be about 10 per cent; hence, the results were considered to be of the same order of magnitude. The laundry was known to bleach in the last soap bath with 2 quarts of sodium hypochlorite of a strength of 1 per cent by weight of available chlorine, or a strength in the actual bath of 0.012 per cent of available chlorine, and to sour with 6 ounces of sodium bisulfite to a bath of 40 gallons of water. The washerwoman was known to use ordinary domestic bar soap and sal soda in undetermined quantities. The appearance of the laundered handkerchiefs were pronounced by impartial judges to be superior to that of the ones washed by the washerwoman.

Another test similar to the above in every way, except that only six washings were made, resulted in a loss of 3.6 per cent per trip to the laundry and 3.8 per cent per trip to the washerwoman. By comparing these results with the ones presented in the previous paragraph, it will be noted that the effect of the washing process is greater per treatment for the first six treatments than for the last four. It would appear that, as the cloth approached pure cellulose in composition, the chemical effect of the washing process becomes less and less, and that all the loss becomes mostly attributable to mechanical effects. Since, however, this is more of academic than practical interest, the writer had to forego further experimentation along this line. The practical interest in the results of the tests is in the fact that a greater loss in strength is suffered in the first few washings than in subsequent ones, and also because the effect of the power laundry process is no greater than the effect of the treatment given by the washerwoman.

Since the above experiments indicated that there was something in the ordinary washerwoman's process that compensated for the bleaching and souring in the power laundry process, the following data were obtained to contribute to an explanation:

### THE LOSS DUE TO BLEACHING

In order to eliminate mechanical influences as completely as possible, the effects of bleaching in a 0.012 per cent available chlorine bath were measured by the following procedure: Test strips of sheeting, about 18 inches square and weighing approximately 25 grams, were prepared and the tensile strength then measured in four places on the warp and four places on the filling. A piece so prepared was then immersed in a 300 cc. bath of sodium hypochlorite of the strength mentioned above, and maintained at a temperature of 180° F. for 15 minutes. The cloth was then removed from the bath, allowed to drain for 2 minutes and immersed in a bath of fiftieth-normal acetic acid, in which it was thoroughly rinsed. The cloth was then rinsed thoroughly in tap water and dried in the centrifuge. This treatment was repeated ten times, using freshly prepared baths each time. After the tenth treatment the cloth was ironed dry and the tensile strength again measured. The average loss per treatment was found to be 1.3 per cent of the original strength.

### EFFECT OF WASHBOARD RUBBING AND THE ROLLER WRINGER

Since all reagents used by the washerwoman and the power laundry are practically identical, excepting the bleach and sour, and since the total effect on strength is approximately the same, this loss due to bleaching and souring in the power laundry process must be represented by the effect of the washboard and roller wringer in the washerwoman's method. It is the opinion of the writer that the centrifugal extractor, as employed in laundries, is one of the pieces of equipment which contribute most to the conservation of fabrics in laundering.

### EFFECT OF DRYING ON CLOTHESLINE

Exposure to the air when drying affects the strength of fabrics more than might be anticipated. A handkerchief was exposed on the roof of a city building for 23 days last July. In this period there were 184.8 hours of sunshine. After this exposure the handkerchief showed a loss of 60 per cent of its original strength. Of course the corrosive effect of substances carried in smoke exerted a decided influence on the results of this test. Undoubtedly under atmospheric conditions prevailing in the country, remote from industrial centers, the effect would be somewhat less. This test, however, furnishes an important object lesson to the city housewife, and, moreover, affords an explanation of the definite way in which lace curtains often fail just at the line marked by the opened sash of the window. Certain hotel managers, appreciating that substances contained in smoke have a corrosive action on fabrics, have their lace curtains laundered more frequently than other considerations would indicate.

The mere effect of hanging clothes on the line, not considering the flapping effect is indicated by the following test: The tensile strength of a handkerchief was measured as described before. It was then dipped in distilled water and hung up to dry. After the operation was repeated eighteen times, the handkerchief showed a loss of 4.35 per cent of its original strength, or a loss of 0.25 per cent for each drying.

### SELECTIVE TREATMENT

When a washerwoman picks up an article to wash it she will intuitively, if she is a good laundress, give the garment the treatment that is required by the nature of the dirtiness and texture of the article. If the article is a garment of thin lawn or nainsook, slightly soiled and perhaps somewhat tendered by age, the washerwoman will rub it less vigorously on the washboard than she would if the article being washed were a pair of white pique trousers that had been worn by a boy of five while at play. In view of the facts suggested in the above statement, the laundrymen have been convinced that in this selective treatment lies the only point of advantage obtaining in favor of the washerwoman as to any superiority in the matter of cleansing or preservation of fabrics. To obtain a compensating advantage in the power laundry, the goods that come from the home are carefully classified, not only as to color, but as to texture, kind of material, and degree of dirtiness as well.

In addition, there are provided, in most plants, special washing machines for the classes represented by the fine cotton and linen garments. Such a machine is termed a "pony washer." When washed in a machine these goods of a more fragile nature are washed with a thick cushion of suds, in order to minimize the mechanical wear.

### SANITARY CONDITIONS

The sanitary features of power laundries have been thoroughly investigated by the Mellon Institute Fellowship, as well as in other laboratories. There is absolutely no chance of disease being spread through the agency of the power laundry. The writer has demonstrated that, even in warm water (40° C.), soap, in concentration equal to that employed in washing woolens, has a bacteriocidal efficiency of 98 per cent for all the common pathogenes. That the high temperatures of the various baths, the ironers, dry houses, and hot-air tumblers, furnish sufficient sterilization, provided the goods are properly handled after ironing or drying, as they are in all good laundries, has been absolutely proved in the Mellon Institute laboratories. Proper handling, after ironing and drying, means that the goods are to be sorted in a room or place remote from the room in which the soiled goods are received.

The results mentioned above are amply confirmed by other investigators, as Wile[9] and Chapin.[10]

### SUMMARY

An endeavor has been made to demonstrate that the responsibility for the conservation of fabrics in laundries is borne by three distinct agents, the manufacturer, the user and the launderer. To last satisfactorily, the fabric must be of good material to begin with. To promote better care in the weaving of fabrics, and to conserve the interests of the honest producers, as well as those of the ultimate consumers and laundry owners, some effective legislation governing proper labeling of fabrics is desirable. Perhaps, also, a pure "ad" law would be for the general good.

The owners of the fabric must understand that the more severely a fabric is soiled the more drastic must be the treatment it receives to restore the original color, whether it be done by the laundress in the home or by the power laundry.

[7] "The Detergent Action of Soap." *J. Chem. Soc.*, Feb. 1917, 86–101.

[8] *J. Ind. Eng. Chem.*, 6 (1914), 640 *et seq.*

[9] *Med. News*, December 3, 1904.

[10] Proc. Rhode Island Med. Soc., 1908.

## Boiler Efficiency*

### Transfer of Heat to the Water

It is now fairly well established that there is a water film adhering to the water side of the plate. The whole of the heat must pass through this film, and as it is stationary the heat transfer must be by conduction. Now water is a poor conductor of heat, and therefore if the resistance is to be reduced the endeavor must be made to break up this inert water film, and bring the main water stream in contact with the plate, just as the gas film on the fireside of the plate must be broken up. Common sense would suggest that the best means of doing this is to allow the water to scour the plates vigorously, or, in other words, obtain good circulation.

CONDITIONS TO BE MET

In addition to breaking up the water film, provision must be made for rapidly liberating the generated steam from the plate surface, else there will be extra resistance, with overheating of the plate. Here again if the water circulation is rapid the steam bubbles as soon as they are formed, will be washed off the plates, and the surface of the latter kept well wetted. Evidently, therefore, the velocity of the water over the plate surface forms a very important factor in quick and economical heat transfer. Further, heat will be more rapidly transferred to a large number of small water streams than to one large tube containing the same volume. Also if the density of the water in the boiler is increased the heat transfer will be retarded, because the denser mixture does not so easily take up the heat.

The actual form of the law governing this portion of the heat transfer was given by Prof. Osborne Reynolds in 1874, and has been confirmed by many experimenters since. The formula is: $H = A + Bpv$, where $H$ = units of heat transmitted per degree difference of temperature of fluid and metal; $A$ = a constant which varies in value with the cleanliness of the heating surface; $B$ = a constant whose value depends on the temperature and on the area of the channel; $p$ = density of the fluid; and $v$ = velocity of flow of the fluid over the metal surface.

The factors governing the constant A have reference to the prevention of scale, and are not of interest for the present purpose. The constant B is influenced by the design of boiler; its value, for instance, would not be the same in a Yarrow as in a Lancashire boiler.

The main factor is the velocity of the water over the heating surface, and the design and operation of the boiler should, as far as possible, provide for and promote good water circulation. In so far as the boiler fails to set up quick, natural circulation, it will fail to respond quickly to varying steam demands, and increased energy will be absorbed in maintaining even moderate circulation.

WATER CIRCULATION

The principal cause of water circulation is the low density of the mixture of steam, hot water, and foam as compared with the same volume of feed water. The rising tendency of this mixture must be adequately provided for, and the area of all water spaces and passages should be such as to give the greatest liberty to the water movements. Provision must also be made for the feed water easily and quickly taking the place of the generated steam, and for the rising steam and water to be easily separated.

One of Wye Williams's early experiments is of great importance in giving an insight into the true principles of water circulation.

Two glass tubes two inches in diameter and 18 inches long are attached at the top to an open tin vessel, and at the bottom to one which is closed. The apparatus is filled with water and heat applied below the bottom vessel. A current of mixed steam and water will be seen ascending in one glass, and water descending in the other. There is no confusion or collision, the steam is easily and completely released, and the cold water finds easy access to the heating surface.

If now a cork is inserted at the top of the glass acting as a downcomer for the feed water and heat applied, then the other glass will have to perform the double duty of allowing the rising steam to reach the surface and the descending water to reach the bottom vessel. Instead of uniform motion there is intermittent action, steam is generated with explosive violence, and the regular supply of feed is prevented.

This experiment clearly demonstrates the importance of correct design in order to provide for easy water movements, easy steam release, and continuous feed supply to the heating surface.

Many important points were revealed by the classical experiments on circulation made by Yarrow. For instance, he found that when once circulation had started in his U tube arrangement the heating lamps could be transferred from the leg in which the mixture was rising to the downcomer without the direction of flow being reversed. Many of his circulation experiments were made with the steam inside under pressure, and the results obtained were therefore more in accordance with the conditions of actual practice.

TANK BOILERS

Broadly speaking, the primary result of making use of quick circulation is to obtain rapid steam generation and not necessarily greater efficiency, though it is certain that less internal energy will be expended where provision is made for the points mentioned above. In other words quick circulation has reference more to boiler capacity than boiler economy. In Lancashire and Cornish boilers the provision for circulation is exceedingly bad. The mixture of water and steam immediately over the furnaces will rise and tend to flow either to the back end of the boiler or over to the curved sides of the shell. It will return along the underside of the furnaces, and up to take the place of the rising mixture at the front end. In this type of boiler a great mass of water has to be set in motion, the path is free and not controlled, and consequently the circulation is sluggish.

Several appliances are on the market for improving the circulation on the Lancashire boiler. In one of these a hood is fitted over the furnace tube, so that the rising mixture of steam and water is directed and propelled towards the back end of the boiler. In another well-known appliance a portion of the heated water from the surface is taken and transferred to the bottom of the boiler, thereby displacing the cooler water and encouraging circulation. These appliances are certainly helpful, but are unable to make a naturally bad circulating boiler into a good one.

In the locomotive boiler the water rises from the surfaces of the firebox and passes along the top to the front of the boiler, then down to the bottom, and back again to the firebox surfaces. Here again there is no controlled circulation. In the Scotch marine boiler the water rises from the furnace tubes and flows along the top surface, down behind and between the combustion chambers, underneath the furnaces, and up again to take the place of the rising steam and water.

In these three types of boilers the arrangements for the water circulation are not at all in accordance with the principles laid down above. In fact, the wonder is that some of the surfaces, as, for instance, the lower portions of the firebox in a locomotive boiler or the back portions of the combustion chamber in a Scotch boiler, are kept supplied with water at all. Of course, the outstanding qualities of these boilers for their special purposes have made this question of water circulation of secondary importance.

WATER-TUBE BOILERS

In water-tube boilers, in which the water currents are directed and controlled, the correct principles of circulation are seen in operation, with corresponding advantages.

In boilers of the Babcock and Wilcox type, in which the tubes are only slightly inclined to the horizontal, the feed water enters the steam drum at the front end, and is delivered to the top of the back header, down which it flows. From this header it passes through the various tubes to the front header. The mixture of steam and water rises in the front header to the steam drum, where the water again joins the main current and the steam separates. As the maximum circulation and steam production is in the bottom tubes, it follows that adequate area must be provided in the back header to keep the bottom tubes well supplied with water. In a modification of this boiler the water passes from the back of the steam drum, down a vertical pipe of large area, into a water drum under the bottom of the back header. A connection is made between this drum and the header, so that a more certain supply of food water becomes available for the bottom tubes.

With water-tube boilers in which the tubes are more nearly vertical, as in the Stirling, Woodeson, Sinclair, Garbe, and others, the headers are dispensed with and the tubes attached directly to the drums. In the Stirling boiler the water enters the back steam drum, along a feed distributing pipe, which ensures an even feed to all the down tubes. The water flows down the back bank of tubes, which are almost vertical, into the back mud drum. From here it passes up the third bank of tubes into the middle steam drum, then down the second bank of tubes to the front mud drum, and up the front bank of tubes to the front steam drum. This is connected by pipes to the middle steam drum, so that the water again passes into the latter and into the main current until evaporated. The circultion is thus exceedingly vigorous and easy, and little energy is wasted in overcoming internal resistance. The tubes are of small diameter, so that the water is in small streams, and good provision is made for the easy release of the steam and for the adequate supply of fresh feed water to the steaming surfaces.

In another group of water-tube boilers, such as the Suckling, the Bettison, and the Wickes, the water tubes are quite vertical. Water is fed to the top drum, and passes down special vertical downcomers to the bottom drum. Vertical tubes of small diameter join the two drums, and in these tubes the water and steam rise. The water circulation in such boilers is exceedingly good.

In all the designs mentioned the circulation is natural. If higher demands are made from boiler-heating surfaces, as seems likely to be the case, then, as the heat transfer on the water side increases directly as the water velocity over the heating surface, a case can be made out for forced circulation.

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